

**Controller Evaluation of CPDLC Services Implemented on the
Display System Replacement (DSR) Workstation:**

**Study 2 – Assessment of the Build I and IA Human-Computer
Interfaces, Training, and Procedures**

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16. Abstract This report presents the results of the second in a series of studies being conducted by ACT-350 of the Federal Aviation Administration (FAA) William J. Hughes Technical Center to evaluate and refine the controller human-computer interface (HCI), air traffic procedures, and training for Controller-Pilot Data Link Communications (CPDLC).			
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EXECUTIVE SUMMARY

This report presents the results of the second in a series of studies being conducted by ACT-350 of the Federal Aviation Administration (FAA) William J. Hughes Technical Center to evaluate and refine the controller human-computer interface (HCI), air traffic procedures, and training for Controller Pilot Data Link Communications (CPDLC). The objectives of this study were to: (1) evaluate a prototype CPDLC I controller training program; (2) obtain a final review of the CPDLC I HCI based on the evaluations of controllers from the key site Miami Air Route Traffic Control Center (ARTCC) using local airspace and air traffic scenarios; (3) conduct an initial review of the HCI and functionality for services that will be added under CPDLC IA; and (4) test CPDLC procedures for atypical event recovery.

Six en route Air Traffic Control (ATC) Specialists recruited from the Miami ARTCC and the Air Traffic Display System Replacement Evolution Team (ATDET) participated in the study. The first week of the study focused on CPDLC I. Controller CPDLC I training was conducted using a prototype program which included lecture and Computer-Based Instruction (CBI) components. The controllers then performed a training program evaluation. After subsequent proficiency practice in the high fidelity Display System Replacement (DSR) simulation laboratory at the Technical Center, the controllers completed individual design reviews and participated in a group debriefing on the HCI and functionality provided by the CPDLC I services. Finally, the controllers participated in simulation scenarios designed to test procedures for CPDLC I failures, errors, and other atypical events.

The second week of the study was devoted to an initial evaluation of the five services that will be added with the implementation of CPDLC IA. Following training and proficiency practice, the controllers completed individual questionnaires and participated in a group debriefing to evaluate the functionality and HCI provided for the services. Additional testing was then conducted to permit observation and evaluation of procedures for recovery from CPDLC IA failures, errors, and atypical events.

Controller evaluations of the functionality and HCI provided for CPDLC I indicated that they were acceptable and that no additional modifications will be necessary to ensure safety and operational acceptance for the limited key site deployment. However, the controllers recommended that several improvements be made to the four initial services as they are transitioned to CPDLC IA. These included the conversion of CPDLC lists to DSR views, addition of CPDLC data entry and display capabilities to the Radar Associate Controller (RAC) position,

and the use of an alternative display of the initial contact mismatch condition in the Full Data Block (FDB).

Evaluations of the CPDLC I prototype training package yielded several recommendations for improvement of the HCI design for the CBI and the sequencing of some training events. These findings will be forwarded to the FAA Academy for use in the development of the operational training program.

Controller assessments of CPDLC IA identified specific design improvements as well as recommendations for future testing of some alternative display options. Overall evaluation of the speed, heading, and altitude services indicated that they were acceptable as tested. However, the controllers recommended that alternative methods for presenting message content and status in the FDB be explored and tested.

The controllers also recommended that the alerting qualities of the FDB indication of the arrival of an altitude request downlink should be improved. In addition, the system should include a capability to display downlinks at the RAC position. Other suggestions included testing of multilevel alerting schemes for atypical events that would optimize detection while minimizing visual disruption and distraction, and increasing the size of the symbols used to indicate the existence of a Data Link session and eligibility in the FDB.

Testing conducted to evaluate procedures for handling atypical events, errors and failures in CPDLC I and IA revealed a small number of needed improvements. Results showed that all atypical message states scripted during high traffic scenarios were detected by the controllers and indicated that alerts for these events were effective. However, expert observers found that controllers did not normally notice that an aircraft had lost its Data Link session when this occurred outside of a CPDLC transaction. The controllers recommended that a positive indication of lost session be displayed to improve detection.

Multiple open downlink messages from a single aircraft created controller uncertainty that required voice coordination for resolution. The participants recommended that pilot procedures be developed or CPDLC design features added to preclude more than one open altitude request from any single aircraft. Finally, testing identified required improvements in procedures for situations in which Data Link transactions must be deleted by controllers and/or resolved by voice radio.

1. INTRODUCTION.

1.1 PURPOSE.

This document presents the findings of the second of a series of studies being conducted by ACT-350 of the Federal Aviation Administration (FAA) William J. Hughes Technical Center to evaluate and refine the controller human computer interface (HCI), air traffic procedures and training for Controller-Pilot Data Link Communications (CPDLC). The testing described here is in accordance with the recommendations and goals presented in the CPDLC Roadmap for Human Factors Activities (Data Link Human Factors Working Group, 1998).

1.2 CPDLC IMPLEMENTATION PLANS.

CPDLC is a Data Link system that will provide discretely addressed digital communications between air traffic controllers and pilots. CPDLC will supplement the current voice radio channel to increase communications system capacity and enhance safety in the National Airspace System (NAS).

The goal of the FAA is to field a full en route CPDLC application by 2005. This will be accomplished under a phased approach. The initial phase (CPDLC I) will introduce the messages required to provide four non-time-critical services: Transfer of Communication (TOC), Initial Contact (IC), Altimeter Setting (AS), and a free text menu capability (MT) used to send informational messages to the flight deck. The Miami Air Route Traffic Control Center (ARTCC) will be the key site for fielding CPDLC I in June 2002.

The plan calls for deployment of the next CPDLC build (CPDLC IA) beginning with a key site implementation in June 2003 followed by national implementation within the next several months. CPDLC IA will expand the message set to support speed, heading, altitude, and route assignments. In addition, an initial capability to accommodate downlinked altitude requests will be included.

Key site implementation of CPDLC II will be initiated in June 2005 with national deployment commencing thereafter. This system build will constitute a mature version of CPDLC capable of fully supporting air traffic control (ATC) operations for the next several years. The message set will provide multipart clearances, report instructions, and an enhanced capability for flight crews to downlink requests and responses to ATC queries. CPDLC III is a far-term (2011+) version of the system, which will further refine air-ground messaging and upgrade to a more robust communications subnetwork.

1.3 CPDLC HUMAN FACTORS REQUIREMENTS.

Successful achievement of the FAA's goals in each of the implementation phases outlined above will depend on the resolution of outstanding human factors issues associated with CPDLC. Focused ground side and flight deck research efforts will be needed to define HCI requirements, develop supporting procedures, and insure that users are provided with effective training programs. Additional high-fidelity simulation testing with both pilots and controllers in-the-loop will be required to validate the end-to-end usability and functionality of the system.

Because of the rapid progression of the implementation schedule, the human factors issues associated with each phase of CPDLC must be addressed as early as possible in the development and testing process in order to have a meaningful effect on the equipment, software, and procedures that reach the field.

1.4 NEAR-TERM CONTROLLER HUMAN FACTORS RESEARCH.

During 1999, the Data Link Branch (ACT-350) of the Technical Center is conducting a series of studies to address groundside, ATC human factors issues associated with CPDLC I and IA. The overriding goals of these studies are to: (1) resolve the controller human factors issues associated with CPDLC I prior to operational test (OT) late in 2000; (2) insure that HCI and procedural decisions made for CPDLC I are compatible with the requirements for future system builds with larger message sets; and (3) provide HCI and service design criteria for CPDLC IA with sufficient lead time to effectively impact the software development cycle.

These studies are taking place concurrently with corresponding flight deck test and development activities and will lead directly to joint controller and pilot in-the-loop testing prior to formal CPDLC I OT in 2000.

The near-term ground side research builds upon over 10 years of prior work conducted by ACT-350 at the Technical Center. Among other products, this research generated a set of thoroughly tested and validated CPDLC services for the Plan View Display (PVD) workstation. The set included the four services that will be provided by CPDLC I (TOC, IC, MT and AS) and three of the services added by CPDLC IA (altitude, speed, and heading assignments).

In 1998, ACT-350 conducted a design review intended to obtain preliminary controller inputs to the HCI for transitioning the CPDLC services previously implemented on the PVD to the Display System Replacement (DSR) workstation (Darby, 1998). Participants including controllers from the Air Traffic Data Link Validation Team (ATDLVT), DSR team and National Air Traffic Controllers Association (NATCA) examined the HCI design plans and provided

recommendations for DSR CPDLC key assignments, Full Data Block (FDB) symbology, display parameters, and the functionality of the IC service. Based on these findings, ACT-350 proceeded to incorporate the DSR laboratory at the Technical Center into the Data Link test bed facilities and to implement the preliminary designs for CPDLC HCI and functionality in the operational equipment.

More recently, ACT-350 conducted the first of the current series of controller evaluation studies (Darby and Shingledecker, 1999). For this study, the four CPDLC I services were implemented on the DSR in order to permit them to be exercised in basic air traffic scenarios. Following four hours of dynamic simulation experience with CPDLC I, eight controllers completed individual design reviews and participated in a group debriefing on the HCI and functionality provided by the baseline CPDLC I services. The controllers also were exposed to baseline designs for the downlink and route assignment services required for CPDLC IA and made preliminary recommendations for design changes in a group debriefing.

The study yielded several essential design changes for CPDLC I. These included improved visual emphasis for status list entries which may require controller action, more distinctive FDB symbols for Data Link, a more useable Data Link Settings HCI, and more accessible locations for Data Link keyboard keys.

2. OBJECTIVES.

This document presents the results of the second study conducted to refine the controller HCI for CPDLC through Build IA, validate proposed CPDLC procedures, and assess controller training techniques.

The specific objectives of this study were to:

- a. Evaluate a prototype CPDLC I training program including lecture and Computer-Based Instruction (CBI) elements.
- b. Obtain a final review of the CPDLC I HCI based on the evaluations of controllers from the key site Miami ARTCC using local airspace and air traffic scenarios.
- c. Conduct an initial review of the HCI and functionality for services that will be added under CPDLC IA.
- d. Test CPDLC procedures for atypical event recovery.

3. TEST CONDUCT.

3.1 TEST PARTICIPANTS.

The participants in this study were six en route ATC specialists and supervisory ATC specialists. The ATC specialists were members of NATCA. One supervisor and three of the controllers were recruited from the Miami ARTCC. Two of these were drawn from Area 2 and two from Area 3. The two remaining participants (one controller and one supervisor) were members of the Air Traffic DSR Evolution Team (ATDET). The function of ATDET is to oversee and approve the implementation of new functionality on the DSR HCI.

During training and testing activities, the six participants were divided into two teams of three controllers. One of the teams was composed of the two Miami ARTCC controllers from Area 2 and an ATDET member. The other team included the two Miami ARTCC controllers from Area 3 and the second ATDET member. Each team was assigned to control simulated air traffic in an airspace sector in which the respective Miami ARTCC team members were currently certified.

3.2 TEST FACILITIES AND AIRSPACE.

The study took place in the Technical Center facilities used to conduct high-fidelity simulations of ATC operations. The DSR laboratory houses the en route controller workstations that were used for the simulation exercises conducted during this study. This laboratory is configured to duplicate a field installation, providing direct connection to the Host Computer System (HCS). The functions of the Data Link Applications Processor (DLAP) were emulated by a Sun workstation. The Sun workstation also injected time delays to simulate system transaction and pilot response delays to uplinked CPDLC messages. Transmission delays were varied over the upper portion of the range specified by the CPDLC IA specification. The one-way transmission delays were randomly selected from a rectangular distribution ranging from 5 to 11 seconds. Pilot delays were determined by the actual response latencies of simulation pilots who were responsible for controlling multiple aircraft during test scenarios. However, the minimum pilot delay permitted by the Sun workstation was 5 seconds.

The pilot functions were provided using the Dynamic Simulation (DYSIM) training capability of the DSR. Under the DYSIM mode of operation, operators working at DSR consoles had the ability to receive and send both Data Link and voice radio messages, and to make inputs to realistically maneuver aircraft in response to controller clearances.

Two low altitude airspace sectors from the Miami ARTCC were used for CPDLC training and testing. Sector 20's (Area 2) primary responsibility is the sequencing of arrival traffic inbound to the South Florida area. Sector 47 (Area 3) controls aircraft outbound from Miami International Airport that must be dispersed as they depart for their respective destinations. Sector 47 traffic also includes overflights, arrivals to Palm Beach airport, and arrivals/departures from Regional Southwest Approach Control.

Air traffic scenarios were derived from DYSIM scenarios originally developed and calibrated by the Miami ARTCC for controller training and proficiency evaluation in the two test sectors. Scenarios used for the study activities described in section 3.3 varied along two dimensions. *Traffic density* ranged between 70 and 100 percent of that actually experienced in the respective sectors. A 100-percent traffic scenario contained a peak number of aircraft handled by the sector during a heavy rush period. *Scenario complexity* was defined as the amount of controller intervention required to maintain aircraft separation, as well as the level of demand for controller actions to follow air traffic procedures required by current conditions in the sector (e.g., weather). Low complexity scenarios, which require minimal controller intervention to achieve aircraft separation, were used for initial practice sessions with the CPDLC HCI. Subsequent proficiency practice and special testing sessions were conducted with scenarios in which complexity was comparable to that normally experienced in the test sectors at the Miami ARTCC.

3.3 TEST PROCEDURES.

The study was conducted over a period of 2 weeks. Upon arrival at the Technical Center, the participants received an overview briefing describing the objectives of the study, the activities to be conducted, and their responsibilities in assessing CPDLC on the DSR.

3.3.1 DSR and Airspace Familiarization.

In order to prepare the controllers for subsequent CPDLC training and testing, the study began with a DSR DYSIM training exercise. The participants from the Miami ARTCC had completed preliminary DSR CBI lessons at their facility prior to arriving at the Technical Center for the study, but had not completed required DYSIM training. ATDET participants were proficient in the use of DSR, but were unfamiliar with the test airspace. This initial DYSIM activity was used to provide the two groups with the airspace knowledge and DSR skills necessary for effective participation in the study. During the exercise, the Miami ARTCC controllers familiarized the ATDET controllers with sector airspace, traffic patterns, and procedures. In addition, the ATDET controllers assisted the Miami ARTCC controllers as they gained proficiency in interacting with the DSR HCI.

The training exercise used 70 percent, low complexity scenarios, and were divided into three 1-hour sessions. During each session, two of the controllers at a sector staffed the Radar and Radar Associate control positions, while the third observed. The controllers rotated duties between sessions to provide all team members with experience at both control positions. To insure that they were familiarized with all key functionality, the Miami ARTCC controllers were required to complete a checklist of tasks developed for DSR hands-on training while performing their rotations at the Radar and Radar Associate positions.

3.3.2 CPDLC I Prototype Training and Evaluation.

The second day of the study was devoted to CPDLC I training using a program developed by the CPDLC I Training Team consisting of representatives from the training contractor, the FAA Academy, ATX-100, ARN-100, and NATCA . This training program was designed to teach controllers to use a version of CPDLC I originally planned for a limited field deployment using the ARINC Communications Addressing and Reporting System (ACARS) subnetwork. While the two are largely identical, certain aspects of the CPDLC I (ACARS) prototype HCI differ from the CPDLC I Aeronautical Telecommunications Network (ATN) production HCI that was tested during subsequent phases of this study (e.g., the FDB symbol set and some command inputs).

The CPDLC I (ACARS) training program was used as a prototype in this study to obtain controller feedback about the adequacy of the training format, level of detail provided in the materials, and the duration of the various components.

The prototype training program contained three elements: (1) an introductory lecture; (2) six self-paced CBI lessons with embedded testing; and (3) an air traffic procedures lecture. An instructor from the FAA Academy conducted the lecture sections. The CBI lessons were presented to the controllers on an individual basis using PC-based training workstations that were installed at the Technical Center. At the conclusion of the training activity, the controllers completed a questionnaire and participated in a structured debriefing conducted by the instructor to evaluate the format and content of the program.

3.3.3 CPDLC I (ATN) Training Update.

The third day of the study began with a 1-hour lecture session to introduce the CPDLC I (ATN) HCI as currently proposed for implementation at the Miami ARTCC key site. The lecture emphasized those aspects of the HCI that differ from the system trained on the preceding day.

The controllers then proceeded to the DSR laboratory for a training exercise during which they completed a checklist of CPDLC I (ATN) tasks while

controlling traffic (see appendix A). These tasks required the controllers to exercise all of the Data Link settings controls, send the transfer of communications message using both the manual and automatic modes, observe the FDB displays of transaction status and equipage/eligibility, and experience failure displays including “time-out” and IC altitude mismatches. Each team of controllers rotated between the positions at their sector in order to provide them with experience in the Radar and Radar Associate controller CPLDC I inputs. All aircraft in the low complexity 70 percent scenarios were Data Link equipped and had active sessions established.

The results of the first DSR CPDLC study indicated that improved display emphasis will be needed to alert controllers when a Data Link transaction has an atypical status (i.e., Fail, Error, Time Out, Unable). In order to evaluate one option for providing additional alerting, atypical status list entries were blinked (on/off) on a 1.5-second cycle during CPDLC I (ATN) training and subsequent proficiency practice.

3.3.4 CPDLC I (ATN) Proficiency Practice.

Following the initial training with the CPDLC I (ATN) HCI, the participants began an extended period of practice intended to provide them with the operational experiences necessary to making a professional evaluation of the inputs, displays, and service functionality.

Proficiency practice was completed in three sessions with the controllers rotating between positions during each session. The first practice session was conducted using a 75-percent normal complexity scenario with all aircraft Data Link equipped. In the second session, the participants controlled traffic in a 90-percent scenario with all aircraft Data Link equipped. For the third session, the scenario was advanced to 100 percent traffic. During this final session, only 80 percent of the aircraft had active Data Link sessions. Host computer System Analysis Recording (SAR) tapes from this session were saved in order to extract occurrences of controller attempts to uplink messages to unequipped or ineligible aircraft.

3.3.5 CPDLC I (ATN) HCI and Functionality Design Review.

A detailed evaluation of the CPDLC I design was conducted on the fifth day of the study. Each controller performed an independent evaluation by completing the questionnaire items contained in a design review booklet (see appendix A). The booklet structured the controller evaluations around five primary topics: (1) Data Link FDB and Status List Displays; (2) TOC; (3) MT; (4) IC; and (5) AS.

The displays and inputs for each service were presented for individual evaluation using descriptive text and graphics. The controllers were instructed to provide an overall evaluation of each service design, and to record any required design modifications resulting from a conflict between the proposed CPDLC design and DSR design conventions. They were also asked several specific questions regarding the adequacy of displays, FDB symbols, and alerts, and the acceptability of the data inputs for each service.

The primary focus of this design review was to identify any aspects of the HCI for TOC, IC, AS, and MT that must be modified prior to the limited implementation of CPDLC I in order to assure safe operations and reasonable use of the system by controllers in the field. Consequently, in their evaluations the controllers were asked to distinguish between service design changes that are required for CPDLC I, and those that are needed, but can be safely deferred to the national implementation of CPDLC IA.

3.3.6 Structured Design Review Debriefing.

The individual design review was followed by a structured group discussion and debriefing session. The session was used to perform an item-by-item review of the controllers' responses to the design review questions and ratings. The emphasis of the debriefing was to identify and resolve any disagreements regarding the suitability and acceptability of the CPDLC I HCI design. In addition, the debriefing was used to solicit the controllers' opinions regarding the potential utility of the CPDLC I message set and any operational advantages that it may provide to en route controllers. The group discussion was documented in notes recorded by test personnel and on an audiotape record for reference during data analysis and report preparation.

3.3.7 System Error, Atypical Event and Procedures Testing.

The final activity of the first week examined the effectiveness of preliminary procedures developed for handling system errors and atypical CPDLC events. The controllers first participated in a discussion session during which several potential CPDLC I error conditions, system failures and proposed mitigating controller procedures were reviewed. The proposed procedures were derived from the current draft of *Air Traffic Control Procedures for Domestic Controller Pilot Data Link Communications, Order 7110.XX* under development by the FAA. The controllers were encouraged to assess the potential effectiveness of these procedures and to generate alternative actions.

The controllers then returned to the DSR laboratory for three testing sessions to evaluate the proposed procedures. Each session consisted of a 100-percent traffic scenario into which a subset of the incidents were injected at

unpredictable times. The controllers rotated between the Radar and Radar Associate positions between sessions. Test personnel who are en route controllers and are familiar with CPDLC acted as observers during the test sessions. The observers were given a list of the events that would occur during the scenario along with the simulation time at which the events were injected. As each event occurred, the observers recorded whether or not the participating controllers detected the error and anomaly conditions in a timely manner. If the events were detected, the observers determined whether the defined recovery procedures were followed, and whether they were effective.

The events scripted for each test sector included:

- a. IC altitude mismatches,
- b. Timeout indications during TOC,
- c. TOCs errors and failures,
- d. MT errors, failures, and timeout indications,
- e. Losses of Data Link session with an aircraft not associated with a transaction.

Following the testing sessions the controllers participated in a structured group debriefing session designed to elicit their opinions regarding the effectiveness of the procedures and the potential impact of the errors and anomalies on system performance and safety.

3.3.8 CPDLC IA Training.

The second week of the study was exclusively devoted to an initial evaluation of the services that will be added with the implementation of CPDLC IA. These services are: altitude, speed and heading clearances; route assignment; and altitude requests downlinked from the flight deck.

The week began with a 2-hour lecture session to introduce the HCI for the new services. This was followed by a DYSIM training exercise during which the controllers complete a checklist of CPDLC IA tasks while controlling traffic (see appendix A). These tasks required the controllers to send manually entered speed, heading and altitude clearances, clearances selected from the Menu Text list, modify an aircraft's route using Data Link, and respond to downlinked altitude requests.

Each team of controllers rotated between the positions at their sector in order to provide them with experience in the Radar and Radar Associate controller CPDLC IA inputs. All aircraft in the 70-percent low complexity scenarios were Data Link equipped.

A second option for enhancing display emphasis for transactions having an atypical status was presented during the entire second week of training and proficiency practice. Rather than blinking the status list entry, the entry was displayed in yellow at a level of brightness twice that of other text in the list.

3.3.9 CPDLC IA Proficiency Practice.

Following this initial training with the CPDLC IA HCI, the participants began an extended period of practice intended to provide them with the experiences necessary to make a professional evaluation of the inputs, displays, and service functionality.

Proficiency practice was completed in three sessions with the controllers rotating between positions during each session. During these sessions the controllers had the new CPDLC IA services available for use, as well as those carried over from CPDLC I. The first session was conducted using a 75-percent normal complexity scenario with all aircraft Data Link equipped. In the second session, the participants controlled traffic in a 90-percent scenario with all aircraft Data Link equipped.

For the third session, the scenario was advanced to 100 percent traffic. During this final session, only 80 percent of the aircraft had active Data Link sessions. Host computer SAR tapes from this session were maintained in order to extract occurrences of controller attempts to uplink messages to unequipped or ineligible aircraft.

3.3.10 CPDLC IA HCI and Functionality Design Review.

A detailed evaluation of the services added by CPDLC IA was conducted following proficiency practice. Each controller performed an independent evaluation by completing the questionnaire items contained in a design review booklet (appendix A). The booklet structured the controller evaluations around six primary topics: (1) Altitude Assignments; (2) Speed Clearances; (3) Heading Clearances; (4) MT Clearances; (5) Route Assignments; and 6) Downlinked Altitude Requests.

The displays and inputs for each service were presented for individual evaluation using descriptive text and graphics. The controllers were asked to provide an overall evaluation of each service design, and to record any recommended or

required design modifications. They also were asked several specific questions regarding the adequacy of the functionality provided by each service, as well as the acceptability of displays, FDB symbols, and alerts.

3.3.11 Structured Design Review Debriefing.

The individual design review was followed by a structured group discussion and debriefing session. The session was used to perform an item-by-item review of the controllers' responses to the design review questions and ratings. The emphasis of the debriefing was to identify and resolve any disagreements regarding the suitability and acceptability of the CPDLC IA HCI design. The group discussion was documented in notes recorded by test personnel and on an audiotape record for reference during data analysis.

3.3.12 System Error, Atypical Event and Procedures Testing.

Following the design review, testing was conducted to examine the effectiveness of preliminary procedures developed for handling system errors and atypical events associated with the services added under CPDLC IA. The controllers first participated in a discussion session during which several potential incidents, error conditions, and system failures were reviewed along with proposed mitigating controller procedures. The proposed procedures were derived from the current draft of *Air Traffic Control Procedures for Domestic Controller Pilot Data Link Communications, Order 7110.XX* under development by the FAA. The controllers were encouraged to assess the potential effectiveness of these procedures.

The controllers then returned to the DSR laboratory for three testing sessions to evaluate the proposed procedures. Each session consisted of a 100-percent scenario into which a subset of the critical incidents was injected at unpredictable times. The controllers rotated between the Radar and Radar Associate positions between sessions. Test personnel who are en route controllers and are familiar with CPDLC acted as observers during the test sessions. The observers were given a list of the events that would occur during the scenario along with the simulation time at which the events were injected. As each event occurred, the observers recorded whether or not the participating controllers detected the errors and incidents in a timely manner. If the events were detected, the observers determined whether the defined procedures were followed, and whether they were effective.

The events scripted for each test sector included:

- a. Multiple downlink requests,

- b. Timeout, fail, and error states with altitude clearances,
- c. Loss of Data Link session with an aircraft not associated with a transaction,
- d. Unable responses to messages sent using MT.

Following the testing sessions the controllers participated in a structured group debriefing session designed to elicit their opinions regarding the effectiveness of the procedures and the potential impact of the errors and anomalies on system performance and safety.

4. RESULTS.

4.1 CPDLC I PROTOTYPE TRAINING PROGRAM EVALUATION.

One of the objectives of the study was to evaluate a prototype of the CPDLC I training program and to provide controller feedback to aid in the development of the CPDLC I (ATN) training program that will be implemented at the key site. Controllers were given classroom and computer-based instruction and were asked to complete assessment forms rating those instructions and lessons. During CBI, they were also asked to note any system problems or software bugs on an error sheet.

4.1.1 Student Assessment of Classroom Instruction.

Controllers agreed that the course and lesson objectives were clear. In addition, a majority indicated that overall the lesson was adequate to teach the objectives. However, the controllers concluded that better context for the lecture and discussions may be provided if the procedures lecture is delivered after the students have run a practice scenario in DYSIM. It was also noted that the nonsequential nature of CPDLC operations should receive more emphasis in the procedures lecture.

Lesson graphics, overheads, and other visuals were rated as relevant as well as easy to read and understand. One controller stated that fewer graphics and visuals would have been sufficient since the oral presentation was clear and easy to understand. While controllers were almost evenly split on the quality of the lesson handouts and materials, a majority indicated that they needed improvement.

Controllers found the examples used in the lessons acceptable although the slide for deleting a message was specifically mentioned as a poor example.

Additionally, controllers indicated that learning the material was facilitated by the lesson activities and exercises.

A majority of the controllers indicated that the lessons held their interest. The controllers agreed that sufficient opportunities were provided for asking questions, and that good discussions often resulted.

4.1.2 Student Assessment of CBI.

Controller responses indicated that the objectives/goals of the lessons were clear and that the lesson content supported the objectives/goals. In addition, although controllers noted that there was room for improvement, a majority responded that the lessons were adequate to teach the objectives. It was noted that there was a lot of information to cover in the CBI.

Controllers agreed that the information presented in the CBI was well organized and logical and that the pacing of the instruction was comfortable. However, not all felt that they were able to keep track of their location in the lesson at all times. They commented that the indication to proceed to the next screen was not always apparent and that a signal to proceed (perhaps highlighting the "Next" button or an audio signal) would be helpful to prevent the student from proceeding during a pause in the oral presentation associated with a screen. Additionally, controllers found that the "slew ball to Next" action was time consuming and suggested the use of the Enter key to proceed to the next screen. Controller opinions were split on the clarity of the directions. They stated that, contrary to the narrative, function keys could not be used and that the distinction between keyboard and trackball actions was not always made clear. They noted that the DSR function keys and slew ball should be operational throughout the lessons.

While the majority of the controllers indicated that the lesson content and instructions were of good quality, they were split on the clarity of the content and the examples. Controllers commented that there were too many acronyms, and that a reference sheet listing the acronyms and their meanings would be helpful. They also indicated that the narration should state clearly which functions and options are available in the lesson.

The majority of the controllers felt that the audio and narrative were clear and supported the teaching points. However, one controller perceived a defect in the digitally recorded narration. All controllers agreed that the on-screen information was easy to read and that the graphics and the examples clearly illustrated the concepts being taught.

Controller responses indicated that the activities and exercises were adequate and appropriate to teach the materials but that improvements could be made. They commented that some of the examples assumed knowledge not taught and that more examples and task repetitions are needed.

A majority of controllers indicated that the embedded test items were well written but that improvements should be made. Some questions lacked clarity and the type of response required was not always apparent.

4.2 CPDLC I DESIGN EVALUATION.

The findings presented below are a synthesis of the inputs that were obtained from the independently written controller design reviews and the structured group debriefing. It should be noted that the review and debriefing focused on identifying aspects of the design that must be changed to ensure safety and user acceptance during the limited deployment of CPDLC I at the key site. A secondary objective of the review was to identify modifications to the designs for the TOC, MT, IC, and AS services that would be desirable for incorporation into CPDLC IA.

4.2.1 Overall Acceptability of CPDLC I.

The design review was structured to obtain an evaluation of all aspects of the HCI and functionality provided under the current design for CPDLC I. The controllers evaluated the input commands, displays, and capabilities of the four individual services, as well as the design of the FDB indicators, status list, and special Data Link keys used by all services.

Independent design review questionnaires completed by each of the six controllers unanimously indicated that the design and functionality examined during testing was acceptable for CPDLC I, and that no modifications were needed to ensure safety and operational acceptance for the key site deployment. This consensus was confirmed during the structured group debriefing.

4.2.2 Status List Alerts for CPDLC I.

The results of the first study in this series (Darby and Shingledecker, 1999) showed that the atypical status indications (NEG, UNA, FAI, ERR, TIM) provided in the status list were not sufficiently obvious to reliably alert the controller and prompt any needed action. The present study examined two options for increasing the alerting value of these indications in CPDLC I. During the first week of testing, the message entry in the status list blinked (on/off) at a 1.5-second rate when a message had an atypical status. During the second week,

these status list entries were displayed in yellow at twice the intensity of other entries in the list.

The participants agreed that the blink alert was very effective in drawing the controller's attention to the status list and that it would be an acceptable option for CPDLC I. However, several objections to this form of alerting were noted during the debriefing. Three controllers indicated that the blinking display was distracting and was difficult to read because the text was available for only 50 percent of the viewing time. One controller also noted that the level of alerting implied by blinking was too high for CPDLC because this type of alert is currently used in en route ATC to signal potential emergency conditions (e.g., conflict alert).

The effectiveness of a blinking alert as well as the distraction reported by the participants is likely to be attributable to the fact that the controllers typically positioned the status list near the edges of the display screen to avoid interference with viewing aircraft tracks and FDBs. Thus, when focusing on air traffic, the status list was presented in the peripheral visual field where the visual system was most sensitive to movement and variations in light intensity.

Given the effectiveness of the blinking alert, the controllers offered two potential solutions to minimize required viewing time and reduce distraction. One of the participants recommended that the controller should have the ability to cancel the blinking by a trackball input to the status list entry. A second recommended that flashing (dim/bright) be used as an alternative to blinking in order to distinguish the alert from higher priority alarms and to make the display continuously readable.

The double-bright yellow alerting option that was examined during the second week of testing was evaluated favorably by a majority of the participants. The combination of the color and intensity cues was judged to be less distracting than the blinking display. However, some of the controllers felt that this alert may not have been as effective as blinking.

4.2.3 Design Improvements for CPDLC IA.

While not considered essential for the limited implementation of CPDLC I, the participants recommended several enhancements to the four initial services as they are transitioned to CPDLC IA for national deployment.

a. Change Lists to Views

In agreement with the findings of the first study, the controllers recommended that Data Link lists (status list and menu text list) be implemented

as DSR views not as Host lists. This modification would make Data Link functionality consistent with the view-oriented DSR display conventions, and would provide the semi-opaque view display capability and ease of interaction offered by DSR. Additionally, many of the list filtering functions currently performed through the Data Link settings commands could be incorporated into view pick areas.

b. Indication of Aircraft CPDLC Capability

The current design uses FDB symbols to indicate whether an aircraft has an active Data Link session and whether the viewing controller is eligible to communicate with the aircraft. No provision is made to distinguish between an aircraft that is not Data Link equipped and (1) an aircraft that is Data Link equipped but is not logged on to the CPDLC system; or (2) an aircraft that is equipped and is logged-on, but does not have an active session. In addition, the system offers no means to determine the Data Link status of aircraft that are expected to enter a controller's sector in the near future.

Because of these limitations, the controller has no basis for attempting to start a Data Link session with an equipped aircraft that has logged on to the system but has lost connectivity. Perhaps more importantly, as equipage levels increase in the future, the lack of advance knowledge of the number, type, and routes of aircraft that are Data Link capable will limit the effectiveness of the controller's sector planning to make the most effective use of voice and Data Link communications.

The participants agreed that CPDLC IA should provide some indication of Data Link capability for each aircraft in a sector and for aircraft that are expected to enter the sector. It was suggested that these data could be provided in the aircraft's flight plan and/or on the flight strip.

c. List Filtering

The tested designs of the Data Link status list and MT text list permit the controller to suppress selected entries to minimize display clutter. Status list entries can be suppressed by transaction status and by message type, while messages in the MT list can be individually suppressed. The controllers recommended that functionality be added to permit a user to momentarily view either of the lists in a fully unsuppressed form, and to return to the selected filtered version on command.

d. Initial Contact

Some of the participants expressed an initial concern that the FDB alert of an IC mismatch between the downlinked altitude and that stored in the NAS database was too distracting, and suggested that the information should be confined to a status list display. During the group debriefing, this objection was countered by the argument that the controller is looking at the FDB when assigning an altitude, and that the alert must be presented in the FDB to ensure detection before the clearance is given. While no clear consensus was reached, it was recommended that other methods of presenting the mismatch alert in the FDB be explored and tested for future builds of CPDLC.

Test participants from the Miami ARTCC noted a general problem with the IC service that may limit the use of this service or require a change in local procedures. At some sectors in the Miami ARTCC controllers are permitted to enter an altitude update prior to sending the altitude via voice radio to a climbing aircraft preparing to enter the sector. This preplanned NAS update assists the controller in managing workload when the aircraft will be in conflict with traffic passing through the climb trajectory within the sector. Entering the altitude at which the aircraft will be stopped during the climb prevents a conflict alert false alarm. In addition, the FDB display of the preplanned altitude serves as a reminder of the intended clearance to be sent after the pilot makes the IC call upon entering the sector.

If this practice is followed when CPDLC is implemented, the downlinked IC message sent after the TOC will contain the last altitude sent by the previous controller. The downlink value will not correspond to the preplanned altitude entered by the receiving controller, and will result in a false IC mismatch alert.

The group consensus was that this problem will be accommodated for CPDLC I by a procedural modification or by not using Data Link in the affected sectors. However, they indicated that alternative solutions should be explored for CPDLC IA.

e. Altimeter Setting

In its normal mode, the AS service automatically uplinks an AS to each Data Link aircraft once per sector if the aircraft is at an appropriate altitude. When this automatic uplink occurs the transaction displays are identical to those that are presented for a controller-initiated uplink (i.e., an up-arrow symbol appears in the FDB and an entry is created in the status list).

Several of the controllers noted that these displays of system-initiated uplinks are confusing because they may lead the Radar controller to suspect that

another member of the radar team has sent a message that has not been coordinated. Test personnel explained that the FDB signal was included in the design to direct attention to the status list entry where the controller could verify that the altimeter reporting station is appropriate for the receiving flight. This verification process is an air traffic requirement under existing (voice radio) procedures.

The participants indicated that testing should be conducted for future builds to determine whether removal of the up-arrow from the FDB would impair the controller's ability to verify the AS. It also was noted that as system confidence is acquired in the accuracy of automatic AS, it may become possible to modify the verification requirement and permit the display of only atypical transaction states for automatic altimeter messages that require controller intervention.

f. Radar Associate Controller Inputs and Displays

In further agreement with the results of the first CPDLC DSR study, the participants indicated that enhanced DSR functionality would be needed for the D-side for CPDLC IA. Specifically, the group argued that the D-side controller would find it difficult to monitor Data Link transactions using the status list provided at the R-side position. Likewise, it was suggested that the lack of Data Link keys would place additional memory demands on the D-side controller. The group recommended that the D-side be provided with a status list. The group also recommended that Data Link key functionality (i.e., MT UP, TC UP, DL) be provided at the D-side, either through the addition of keyboard keys, or by including pick areas in the D-CRD.

4.3 CPDLC IA DESIGN EVALUATION.

Section 4.2.3 above summarizes the improvements to the overall HCI and to the four initial Data Link services that were recommended by the participants for inclusion in CPDLC IA. The following sections present the findings of the individual design reviews and group debriefing that were conducted during the second week of the study to assess the functionality and HCI of the five new services that will be added for CPDLC IA.

4.3.1 Altitude, Speed, and Heading Clearances.

The overall evaluations of the altitude, speed, and heading services performed by each controller as part of the individual design reviews indicated that the designs were acceptable as presented. However, the participants identified and agreed upon two specific areas of improvement to enhance the usability of these Data Link clearances.

a. Presentation of Message Content and Status in the Full Data Block

In agreement with controllers who participated in prior development and testing studies of CPDLC using the PVD workstation, the participants noted that an indication of message status and content in the FDB is required for clearances containing altitudes, headings, or speeds. Locating message status and content data in focal vision is necessitated by the technique that controllers adopt when using CPDLC, to send clearances in order to accommodate the time delays that are inherent to Data Link communications.

Specifically, when controllers send a message to an aircraft they use the delay period to continue their scan of the situation display and send messages to other aircraft. They then return to the original aircraft to assess the status of the message. If the data are available only in the peripherally located status list, the controller's scan is disrupted by the requirement to spend "head away" time to determine the message status and confirm its content. The data block must provide content information in addition to message status in order to support short-term memory for the clearance (and overall situation awareness), which can be degraded by the time delay and intervening tasks.

In addition to a status list entry, the altitude, speed and heading service designs that were presented for evaluation during this study provided an indication of message content and status in the FDB. When an altitude assignment was sent, the uplinked value was presented in fields B1-B3 of the data block and an alphabetic character indicating the message status was presented in field B4 (e.g., S, W, F, E). These data timeshared at a 1.5 second rate with the prior altitude value (B1-B3) and the altitude qualifier (B4). Similarly, when a speed was uplinked, the first two digits of the speed and a status character were timeshared with the aircraft's current ground speed in field E. When a heading was sent, the first two digits of the speed followed by the message status character were shown in fields D1-D3 and timeshared with the normal display of the aircraft's Computer Identification (CID) number.

For all three services, the timesharing continued until the message was closed by a response or deleted by the controller. If items, in addition to ground speed, were eligible for display during a speed transaction (e.g., "EMRG") they timeshared in sequence with the sent speed and current ground speed in field E.

The overall timesharing approach described above was developed during prior CPDLC HCI design development studies conducted on the PVD workstation. This design was successfully used by controllers during a high-fidelity simulation study that was performed to assess the benefits of CPDLC in congested en route airspace (Data Link Benefits Study Team, 1995).

While all six participants agreed that the status list entry alone was insufficient for monitoring messages containing altitudes, headings or speeds, four controllers indicated that the timesharing approach used to present status and content information in the data block may not be optimal. Specifically, two controllers noted that the timesharing of the uplinked message data with other information may slow the controller's scan as they wait to determine its status and confirm its content. A third controller also suggested that extra time observing the data block was needed to discriminate between the two and sometimes three different values that are presented in the sequence. One controller also commented that it was possible for as many as three fields to be timesharing simultaneously, and that this would make the display visually distracting.

Given the agreed upon requirement for message content and status indications in the data block for altitude heading and speed uplinks, the controllers recommended that alternative methods be explored for presentation of these data. Two specific options were suggested for future testing and comparison to the effectiveness of the current timesharing design. These were: (1) creation of a fourth line in the data block to present all content and status information, and (2) color coding of the uplinked message content and status in the data block to differentiate these data from other values presented in the same fields during timesharing.

b. Persistent Displays of Transactions Closed by a Positive Response

In the tested designs for altitude, speed, and heading messages, when a transaction is closed by a positive pilot response (i.e., Wilco) its entry in the status list is automatically deleted and the timesharing of content and status information in the data block is stopped. However, these automatic deletions are delayed for a parameter time (nominally 6 seconds) after the response is received from the aircraft. The original design purpose of providing a display of the closed transaction which persisted for a brief time period was to give members of the control team sufficient time to note the successful completion of the transaction and maintain their situation awareness of Data Link communications occurring at the sector.

The participants in the present study concurred that a persistent display in the status list will be a valuable form of system-assisted team coordination when multiple controllers are sending CPDLC messages at a sector. However, they indicated that the persistent timesharing display in the data block was unnecessarily distracting, could mislead the controller into believing that the transaction was still open, and prevented the entry of a new clearance of the same type.

As a result, the group recommended that the closure of an altitude, heading, or speed transaction by a positive response should lead to immediate cessation of the content and status indication in the data block. Conversely, the entry in the status list should remain available for viewing for an adjustable period of time prior to automatic removal from the display.

4.3.2 Menu Text.

All of the participants indicated that the tested design for sending predefined messages from the CPDLC menu was acceptable. Suggested improvements included a reiterated recommendation that the CPDLC menu be presented as a DSR view rather than a Host list. One noted advantage of the view presentation would be simplification of the controller's input action when using the trackball to select a message for uplink.

4.3.3 Route Assignment.

The controllers also agreed that the method for sending a route assignment by modifying current Host route entry commands was acceptable. During the group debriefing the participants asked whether the design would accommodate a wider range of route modification options than the uplinking of route changes to a single fix with a return to the original route that was evaluated during the test. Test personnel explained that, in theory, any options for entering route updates currently accepted by the NAS could be sent via CPDLC. However, it was also noted that these options may be limited by the capabilities of the Data Link avionics that are implemented, or by the usability of the uplinked route by the aircrew. For example, the current method for entering a route by picking locations on the situation display results in the encoding of a series of latitudes and longitudes. Sending these raw position data may not be acceptable or directly useable by pilots unless they are reinterpreted by the avionics system for display.

4.3.4 Downlinked Altitude Requests.

This service provides pilots the ability to downlink an altitude request, and controllers to respond by uplinking the requested altitude assignment, denying the request, or sending a standby message. Of the five controllers who performed an evaluation of the downlink service, all found the format of the downlink list and the inputs to respond to a request acceptable. Two of the controllers suggested that it should be possible to display the downlink list on the D-side to improve capabilities for processing request.

During the design review debriefing, the group noted that replacing the Data Link symbol in the data block with the down-arrow symbol was insufficient as an

alert that a request had been received from an aircraft. In order to test an option for improving the detectability of downlinks, the size of the down-arrow was doubled during subsequent testing of procedures. Observers stationed at each sector noted that detection of arriving downlinks was improved. However, they also noted that detection only appeared to be a problem when the downlink list was not displayed. This suggested that the appearance of the list and/or the movement cues associated with list changes enhanced detection capabilities.

The controllers recommended that other alternatives be tested for increasing the effectiveness of the downlink indicator. Suggestions included displaying the down-arrow in yellow and/or at a brightness level twice as intense as that of other data block characters. One participant recommended that a controllable setting be added to the design to allow the downlink list to appear automatically when a message arrives in order to enhance detection.

4.3.5 Multiple Level Alerting.

Alerts for transactions having an atypical status were originally considered in the design review debriefing for CPDLC I. This topic was reopened after the controllers had worked with the full set of services provided in CPDLC IA where the designs for the altitude, heading and speed services, as well as nonmatching initial contact messages provided both data block and status list for atypical message status. The primary focus of concern with alerts in this study was the dilemma created by somewhat opposing requirements to make alerts sufficiently obvious to attract controller attention while ensuring that they do not cause undue distraction or visual disruption.

In the review of CPDLC I, this dilemma was reflected in the controllers' preference for the use of color in the status list to alert atypical status, and the apparent superior effectiveness of the more distracting blinking alert. In the CPDLC IA debriefing, the problem emerged as questions of whether all atypical transaction states should receive the same level of alerting, and whether redundant alerts were too distracting.

Several controllers indicated that, for example, the timeout alert was not a high priority event requiring immediate attention and should not be alerted at the same level as more important transaction states such as a failed message delivery, or an unable response. Other participants felt that to avoid unnecessary distraction when redundant alerts are used (i.e., status list and data block) they should not be equally salient.

The consensus was that new controller alerting schemes be developed and tested for CPDLC to optimize detection of important atypical events while minimizing visual disruption. Potential replacements for the unidimensional alerting used in

the tested design should consider the assignment of atypical transaction states to one of two categories. States requiring immediate controller attention should be alerted at a high level (e.g., blinking or dim/bright flashing), while those which notify the controller that some action may be needed should be alerted using a less distracting indicator (e.g., color).

In addition, where services have redundant alerts in the data block and the status list, the primary alert should be displayed in the data block and a secondary, less distracting alert, in the status list. For example, if an altitude assignment message is in a failure state and requires a high level alert (e.g., flashing), that indication should appear in the data block, and the status list indication should be displayed using the lower priority, less distracting alert code (e.g., color). Conversely, a message that does not have a data block alert such as TOC should present both high and low level alerts in the status list using the two priority codes described in the preceding paragraph.

4.3.6 Effectiveness of Full Data Block Symbols.

During the first CPDLC DSR study (Darby and Shingledecker, 1999) controllers expressed a strong preference for the use of two specific graphic characters displayed in the data block as indicators of an aircraft's Data Link status. An open diamond was preferred to indicate that an aircraft has an active session but that the viewing controller is ineligible to communicate with the aircraft. A filled diamond was preferred to indicate that an aircraft has an active session and the viewing controller is eligible to communicate with the aircraft. Despite these preferences over other character options, some of the controllers felt that when the data block was set at their preferred font size, the two symbols were too small to ensure accurate interpretation.

In order to determine whether these symbols are sufficiently discriminable from one another, and could be distinguished from the absence of a symbol (aircraft with no active Data Link session), objective data were collected during the present study. SAR tape recordings were analyzed for test runs using scenarios in which only 80 percent of the aircraft had active Data Link sessions. Counts of the number of each type of controller-initiated CPDLC message were obtained as well as the number of attempts to uplink messages to ineligible aircraft and aircraft without active Data Link sessions. Table 1 presents the results of the SAR tape analysis.

TABLE 1. COMBINED SECTOR COUNTS OF CPDLC MESSAGES SENT BY CONTROLLERS AND UPLINK ATTEMPT ERRORS FOR EIGHT 80 PERCENT EQUIPAGE TEST RUNS

Test Run	1	2	3	4	5	6	7	8	Total
CPDLC Build	I	I	I	IA	IA	IA	IA	IA	Sent
TOC	103	74	77	83	114	86	93	87	717
MT (Info Msg.)	91	62	77	72	89	66	74	69	600
Altitude	-	-	-	32	48	26	24	17	147
MT (Clearance)	-	-	-	15	20	18	19	11	83
Route Assign.	-	-	-	7	3	9	5	0	24
Heading	-	-	-	12	14	5	12	2	45
Speed	-	-	-	8	7	1	3	0	19
Total Sent	194	136	154	229	295	211	230	186	1635
Uplink Attempts to Non-DL A/C	0	0	0	0	0	0	0	0	0
Uplink Attempts to Ineligible A/C	4	0	4	1	2	5	8	0	24
Attempt Errors / Tot. Attempts	2%	0%	2.5%	.4%	.6%	2.3%	3.3%	0%	Mean 1.4%
Attempt Errors / Tot. Attempts-TOC	4.2%	0%	5.1%	.6%	1%	3.8%	5.5%	0%	2.6%

The results show that controllers never attempted to send CPDLC messages to aircraft that did not have an active Data Link session in any of the test runs. However, there were a small number of attempts to send messages to aircraft with which the controller was not eligible to communicate via Data Link. Of the 1,659 attempts to send CPDLC messages recorded on the SAR tapes over the 8 test runs, 24 (1.4 percent) were directed to ineligible aircraft. Technically, since the system automatically creates TOC messages for eligible aircraft, these messages do not require the controller to consult the data block symbol to make the decision to send an uplink. If TOC messages are removed from the calculation, 2.6 percent of all uplink attempts were directed to unequipped aircraft. Detailed examination of the times at which each of the attempt errors were made during the scenarios showed that 4 of the 24 occurrences were the result of a controller attempting to send the uplink twice in rapid succession to the same aircraft.

When interpreting these results it should be noted that attempted uplinks to ineligible aircraft are prevented by the CPDLC software which also displays an explicit error message to the controller. Thus, these errors have no safety implications. However, the findings may suggest that some controllers experience minor difficulty in reliably discriminating between the open and filled diamond symbols when displayed at their preferred data block font size. If this

is the case, controller performance could be slowed by the task of determining an aircraft's status performance and by the need to recover from discrimination errors when they occur.

4.4 CPDLC SYSTEM ERROR, ATYPICAL EVENT, AND PROCEDURES TESTING.

Two laboratory sessions were conducted to assess the effects of system errors, atypical events, and the effectiveness of procedures for resolving these incidents. The first session followed CPDLC I proficiency practice and focused on events associated with the IC, TOC, and MT services. During the three test runs the controllers at the two sectors experienced a total of 49 events that had been scripted.

The second session followed CPDLC IA proficiency practice and presented the controllers with atypical message states associated with control clearances, as well as clustered occurrences of downlinked altitude requests. A total of 57 scripted events were successfully injected into the 3 test runs. Table 2 shows the frequency with which each event occurred in the combined CPDLC I and IA sessions and summarizes the findings of the sector observers.

4.4.1 Detection and Responses to Atypical Message States.

As shown in the table, all 48 of the uplink messages having an atypical status (timeout, fail, error, unable) as well as the 13 initial contact altitude mismatches presented during testing were detected by the controllers. Although the Radar controller sent nearly all of the uplink messages, it is noteworthy that a significant number of the negative status indications were first detected by the Radar Associate (D-side) member of the control team, who then notified the Radar Controller.

The expert observers (en route controllers) indicated that the participants' responses to these events were timely in 59 of the 61 cases. One altitude message failure was not acted upon by the control team for approximately 2 minutes. A similar delay was observed for an informational MT message failure. In the latter case, the Radar Associate controller had sent the message to "Call Company." The lack of a status list display at the D-side position may have contributed to the delayed response. However, as shown in the table, neither of these two events nor any of the other 59 events was judged by the observers to have led to a potential safety problem.

TABLE 2. SCRIPTED ATYPICAL EVENTS AND OBSERVERS' FINDINGS

Event Type	Event Total	Number Detected By R/D	Timely Response	Safety Problem	Procedure Issue
IC Mismatch	13	10/3	13	0	No
TOC Timeout	12	9/3	12	0	Yes
TOC Error	5	2/3	5	0	Yes
TOC Fail	4	3/1	4	0	Yes
TOC Unable	2	2/0	2	0	No
MT (Info Msg.) Timeout	4	3/1	4	0	Yes
MT (Info Msg.) Error	5	4/1	5	0	Yes
MT (Info Msg.) Fail	2	2/0	1	0	Yes
Lost Session	8	2/0	1	0	No
Altitude Timeout	2	2/0	2	0	Yes
Altitude Error	4	4/0	4	0	Yes
Altitude Fail	5	3/2	4	0	Yes
MT (Clearance) Unable	3	2/1	3	0	No
Downlinks	37	37	31	0	Yes

4.4.2 Detection of Lost Data Link Session.

In the tested HCI design, when an aircraft loses its Data Link session with the ground system, and this occurs outside of an ongoing CPDLC transaction, the event is signaled to the controller only by the disappearance of the active session/eligibility symbol from the data block. As shown in table 2, controllers detected only two of the eight cases where sessions were lost under these conditions.

During the debriefings, the participants verified that they were rarely aware that a session had been lost unless it occurred while carrying on a transaction with the aircraft (in the latter case, a message failure alert was presented in the status list and/or data block). Neither the observers nor the controllers suggested that the lost session event had ever led to a potential safety problem. However, the participants strongly expressed a desire for a more effective indication of lost sessions. They argued that while an isolated loss of session may have no consequences, the loss of several sessions over a period of time in a high Data Link equipage environment could be an indication of a degrading system. In such a situation controllers would need prompt notification to permit an orderly transition to an all-voice communication mode. One specific recommendation that was made for improving detection was to create an entry in the status list when air-ground connectivity is broken in the absence of an ongoing transaction (e.g., "AAL 456 LOST SESSION").

4.4.3 Responding to Multiple Downlinks.

Table 2 shows that the controllers provided timely responses to downlinked altitude requests in 31 of the 37 occurrences. Delayed responses were normally associated with situations in which multiple downlinks were received in close succession, particularly when more than one request was received from the same aircraft in a short period of time.

Debriefing discussion of this situation indicated that multiple open downlinks from the same aircraft caused confusion because the controller was unsure of which requested altitude was the one that the aircrew actually desired. It was concluded that the uncertainty associated with this situation would require voice coordination, thereby reducing the value of using Data Link for transmitting and responding to altitude requests. The controllers suggested that a flight deck procedure be considered for adoption by the airborne community that would prohibit downlinking a second request until the last has received a response. Alternatively, upon arrival of a second downlink, the Data Link system should delete the first message and uplink a message indicating that the new request had been received.

4.4.4 Procedural Issues.

The last column of table 2 notes events in which procedural issues were identified as a result of observations made during the test runs and debriefing discussions. The testing revealed two related procedural issues associated with situations where a Data Link transaction must be completed or resolved with a voice radio interchange.

a. Notification of Failed Data Link Transactions

The failure (FAI) status for a CPDLC message closes the transaction and indicates that the Data Link session with an aircraft has been aborted. During testing, the participants typically responded to this event by calling the pilot on voice radio to convey the intended message, and deleting the message entry from the status list. Subsequent debriefing discussion indicated that this response alone may lead to pilot confusion and to a reduction in situation awareness on the ground. The participants recommended that procedures should require the controller to notify the aircrew of the link failure during the radio call, and to inform both the Air Traffic Operational Supervisor and the next controller that will handle the aircraft. This suggestion was in agreement with prior recommendations made by the FAA CPDLC procedures team.

b. Deleting Open CPDLC Uplink Transactions and Downlinks

CPDLC functionality permits the controller to delete and close an open transaction. Such actions were sometimes observed during testing when messages were in a timeout status or when a standby response was received. In these cases, the controller had determined that immediate action was necessary, or that because of the passage of time, a new clearance should be sent. Typically, controllers would delete the message and send the required information via voice radio.

Two problems arise in the scenarios identified above. For a message with a standby status, or a message in a time out or error status that has been received by the aircraft, deletion and closure on the ground, leaves the transaction open in the flight deck CPDLC system. If the flight crew responds to the clearance following the deletion, it is rejected by the ground system and an error message is returned. If a message in a timeout status has not yet been received by the aircraft when the message is closed on the ground, and is received after the controller calls with a voice clearance, even more potential confusion could be created on the flight deck.

A similar problem was observed when controllers deleted a downlink transaction. This occurred when a controller chose to contact the aircraft by voice radio regarding the request, or when multiple downlinks from the same aircraft were received and the controller sent a response to one and deleted the other. In both cases, the action taken by the controller left an open downlink transaction in the airborne CPDLC system.

The participants recommended that joint air-ground procedures be developed as a solution to the problems outlined above. Several alternatives were discussed for consideration. At a minimum, these procedures would require controllers to notify the aircrew that a deletion action had taken place as a part of the radio call to the aircraft. However, this notification would not prevent the pilot from receiving an error message. Consequently, in a preferred method for deleting uplinks, the controllers would append an instruction to the pilot to send a response that would close the transaction normally (e.g., unable) in lieu of the deletion action on the ground.

Ideally, the controllers recommended that both the open uplink and downlink problems could be best resolved by a "graceful" transaction closure procedure that would not require lengthy and ambiguous voice coordination to achieve. This method would involve a voice notification message that would inform the pilot that the transaction had been deleted. In combination with this procedure, a function would be added to the airborne system that would permit

the pilot to delete an uplink or an open downlink from the avionics when the notification was received.

5. CONCLUSIONS AND RECOMMENDATIONS.

The results of this study are based on structured controller evaluations, the findings of expert observers, and Host computer System Analysis Recording (SAR) tapes, obtained during a 2-week high fidelity simulation exercise conducted to assess human factors issues associated with the implementation of Controller Pilot Data Link Communications (CPDLC) in domestic en route airspace. The following conclusions and recommendations derived from these results address the controller Human Computer Interface (HCI) and functionality for CPDLC I and CPDLC IA, controller training for CPDLC I, and Air Traffic procedures for the operational use of CPDLC.

5.1 CPDLC I HCI AND FUNCTIONALITY.

a. Acceptability of CPDLC I Design

The six air traffic controllers who participated in this study were recruited from the CPDLC I key site (Miami Air Route Traffic Control Center (ARTCC) and the Air Traffic Display System Replacement (DSR) Evolution Team (ATDET)). After completing proficiency practice in Miami ARTCC airspace using the four services that will be provided by CPDLC I, the controllers unanimously indicated that the HCI and functionality was acceptable, and that no modifications were needed to ensure safety and operational acceptance for key site deployment.

b. Status List Alerting for CPDLC I

The participants evaluated two options for improving the alerting value of atypical message status indications presented in the status list (NEG, UNA, FAI, ERR, TIM). No clear consensus was achieved regarding a preference for blinking or color coding the status list entry. It is recommended that additional options, including bright-dim flashing of the entry and adding the ability to cancel the alert, be evaluated in future studies.

c. Improvements to the Four Initial Services for CPDLC IA

The transfer of communication, initial contact, altimeter setting and menu text services provided by CPDLC I will be included among the services that will be introduced for national deployment under CPDLC IA. The controllers in this study recommended that the following improvements be made to the initial services for CPDLC IA:

1. Implement the status list and menu text lists as DSR views.
2. Add functionality to permit the controller to momentarily view the menu text list and the status list in a fully unfiltered form, and return to the filtered version on command.
3. Provide an indication of aircraft Data Link capability in the flight plan and/or on the flight progress strip.
4. Explore alternative methods of presenting an initial contact altitude mismatch alert in the Full Data Block (FDB) in future research.
5. Examine procedures for accommodating the practice of entering preplanned altitudes procedurally, or in the design of the initial contact service, to prevent false altitude mismatch alerts.
6. Determine whether the up-arrow status indicator in the FDB can be safely eliminated when altimeter settings are automatically sent to aircraft.
7. Provide full CPDLC data entry capabilities and a repeater of the status list at the Radar Associate position.

5.2 CPDLC I TRAINING.

Evaluation of the prototype CPDLC I training program revealed several areas for improvement in the design of the Computer Based Instruction (CBI) and in the sequencing of some training events. It is recommended that the results presented in section 4.1 of this document be used to guide the development of the operational CPDLC I training package.

5.3 CPDLC IA HCI AND FUNCTIONALITY.

5.3.1 Altitude, Speed and Heading Clearances.

Overall controller evaluations of the altitude, speed, and heading services indicated that the HCI designs were acceptable as tested. However, two specific areas for improvement were recommended.

a. FDB Display of Message Content and Status

In agreement with the results of prior research conducted at the William J. Hughes Technical Center, the participants in this study indicated that message content and status information must be presented in the FDB for an ongoing

CPDLC transaction containing an altitude, speed and/or heading. The tested design uses a timesharing method for presenting these data in selected fields of the FDB. Some of the controllers suggested that while this method was effective, it may not be optimal. Alternative techniques were suggested for comparative evaluation in future research. These included: (1) creation of a fourth line in the FDB to display content and status; and (2) color coding of the content and status to make it more distinguishable from other data being timeshared in the same field.

b. Persistence of Displays in the FDB

The controllers recommended that the closure of an altitude, heading or speed transaction by a positive response should immediately remove content and status information from the FDB. However, the entry in the status list showing the positive closure of the transaction should remain viewable for an adjustable period of time.

5.3.2 Downlinks.

a. The controllers recommended that a capability to display the downlink list at the Radar Associate Controller's position should be added.

b. Based on the evaluations of the participating controllers and the observations of expert observers, it is recommended that the alerting qualities of the FDB indication of a downlink be improved. Suggestions for testing included color coding of the down-arrow and displaying the indication at a higher intensity than surrounding data.

5.3.3 Multilevel Alerts.

The controllers recommended that alternative, multilevel alerting schemes for atypical message statuses be tested in future research to optimize detection of important events while minimizing visual disruption. Such schemes should distinguish between higher and lower priority atypical message statuses, and between FDB and status list alerts when redundant alerts are provided.

5.3.4 FDB Symbols.

The results of SAR tape analyses conducted to examine data entry errors suggested that some controllers may experience difficulty in discriminating between the FDB session and eligibility symbols when the FDB is set at small font sizes. It is recommended that these symbols always be displayed at a font that is one size larger than the selected FDB font size.

5.4 ATYPICAL EVENTS AND CPDLC PROCEDURES.

5.4.1 Detection of Atypical Message States.

The results of special testing showed that controllers detected all non-normal message states scripted during high traffic scenarios. This finding indicates that alerts provided for such states in the tested design were effective.

5.4.2 Detection of Lost Session.

Data provided by expert observers indicated that in a majority of cases, controllers did not detect the loss of a Data Link session with an aircraft when this occurred outside of a CPDLC transaction. The controllers recommended that a positive indication of a lost session be provided in CPDLC IA. An indication suggested by the participants was the creation of an entry in the status list to signal such events.

5.4.3 Multiple Downlinks.

Multiple open downlink requests from the same aircraft created uncertainty among the controllers that required voice coordination with the pilot for resolution. The controllers recommended that the airborne community consider adoption of a procedure that would normally prohibit downlinking of a second altitude request until the first request has received a controller response.

5.4.4 Procedural Issues.

Two procedural issues were identified during testing. Both were associated with the scenario in which a CPDLC transaction must be closed or resolved via voice radio.

a. Failed Transactions

In responding to CPDLC messages in fail status, the controllers recommended that procedures require the controller to notify the aircrew, ATC supervisor, and the next controller that will handle the aircraft that the Data Link session with the aircraft has been lost.

b. Deletion of Open Transactions and Downlinks

The participants recommended that additional procedures, and possibly additions to flight deck functionality, be developed to deal with situations in which open uplink or downlink transactions must be deleted by a controller and resolved by voice. Such improvements should be designed to avoid lengthy and

ambiguous voice exchanges and to provide the pilot with an ability to delete open transactions in airborne Data Link equipment.

6. REFERENCES.

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Data Link Benefits Study Team *User Benefits of Two-Way Data Link ATC Communications: Aircraft Delay and Flight Efficiency in Congested En Route Airspace.* **Federal Aviation Administration, FAA Technical Center, Final Report, DOT/FAA/CT-95/4, February 1995.**

Data Link Human Factors Working Group *Controller-Pilot Data Link Communications Roadmap for Human Factors Activities.* **Federal Aviation Administration, 1998.**

7. ABBREVIATIONS AND ACRONYMS.

ACARS	ARINC Communications Addressing and Reporting System
AID	Aircraft Identification (Call Sign)
ARTCC	Air Route Traffic Control Center
ATCS	Air Traffic Control Specialists
ATDET	Air Traffic DSR Evolution Team
ATDLVT	Air Traffic Data Link Validation Team
AS	Altimeter Setting
ATC	Air Traffic Control
ATN	Aeronautical Telecommunications Network
CBI	Computer-Based Instruction
CID	Computer Identification Number
CPDLC	Controller-Pilot Data Link Communications
DL	Data Link
DLAP	Data Link Applications Processor
DS	Data Link Settings
DSR	Display System Replacement
DYSIM	Dynamic Simulation
FAA	Federal Aviation Administration
FAI	Failure
FDB	Full Data Block
HCI	Human Computer Interface
HCS	Host Computer System
IC	Initial Contact
MMAC	Mike Monroney Aeronautical Center
MT	Menu Text
NAS	National Airspace System
NATCA	National Air Traffic Controllers Association
OT	Operational Test
PVD	Plan View Display
SAR	System Analysis Recording
TOC	Transfer of Communication

APPENDIX A

CONTROLLER EVALUATION AND TASK CHECKLIST MATERIALS

**CPDLC I
DISPLAY SYSTEM REPLACEMENT (DSR)
HUMAN-COMPUTER INTERFACE**

CONTROLLER DESIGN REVIEW BOOKLET

This booklet contains a series of questions that will permit you to independently review and evaluate the CPDLC I Human-Computer Interface (HCI) that will be implemented on the DSR. The intent of this review is to obtain a final evaluation of CPDLC I prior to formal Operational Test and Evaluation. The primary goals of the review are to:

1. Insure that the service designs are acceptable for the limited field deployment at the Miami ARTCC.
2. Determine whether there are any changes to the designs that must be made for CPDLC I to assure safety and operational acceptance.
3. Identify changes to the designs that should be made as the services are transitioned to CPDLC IA for national deployment.

Please answer all of the questions in this booklet and carefully record your comments and any recommendations for design changes. Please explain your reasons for suggesting any changes.

Reviewer's Name _____

Instructions

This booklet is divided into six parts that will permit you to make a detailed evaluation of the functionality provided by CPDLC I and the controller interface design. Each part begins with a design description. Read these descriptions carefully before answering the associated questions and recording your comments.

NOTES ON CONVENTIONS USED IN THE DESIGN DESCRIPTIONS

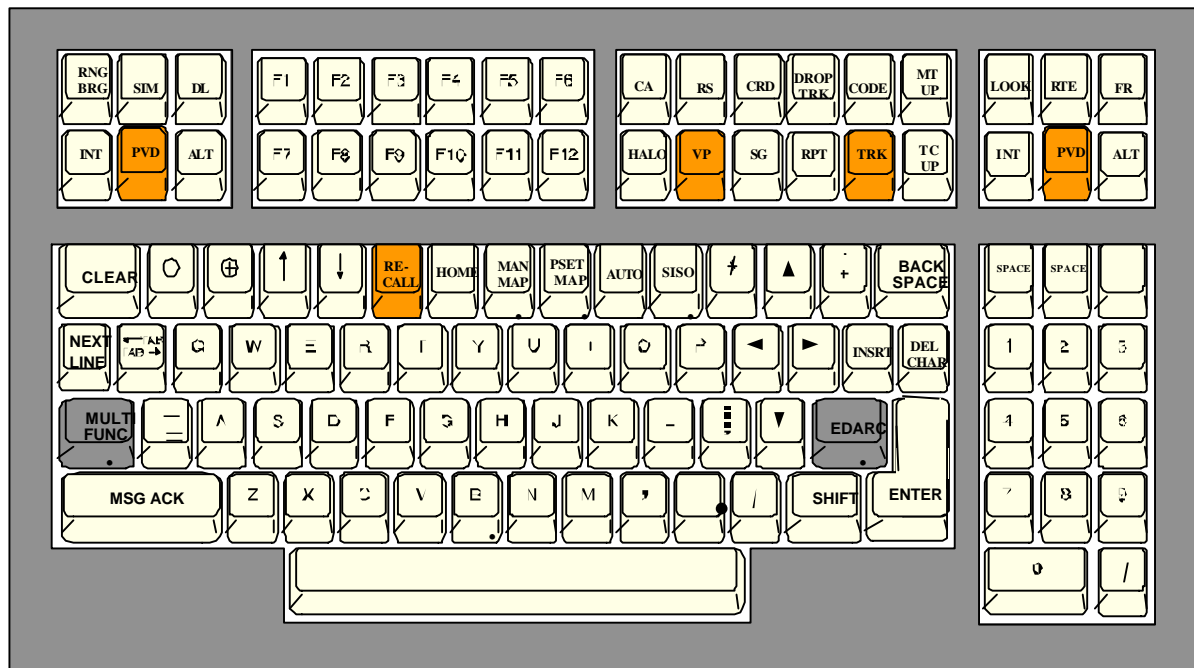
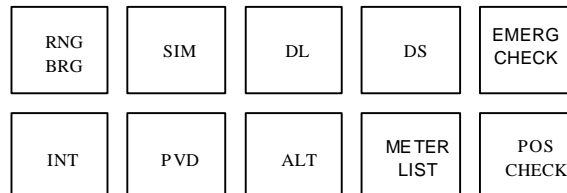
- Data as shown in a display or entered on the keyboard are presented in quotation marks. When spaces are required, they are included within the quotation marks. The quotation marks are not part of the display or entry.
- All spaces included within quotation marks for keyboard entries are mandatory. For example, "MT ON" should be interpreted as typing MT, a space, and ON.
- Input commands printed in bold italics refer to a DSR keyboard category, soft function, or hard function key, or a "key" in the R-CRD Category Selection Area (e.g. *DL*, *DS*, *F1*).
- Two trackball keys are used. Trackball ENTER (middle key) is used to complete a command sequence. Trackball SELECT (left key) is used to identify an item in the R-CRD text area or the status list and to identify lists for moving them on the display.
- FLID refers to any NAS command for identifying a flight including:
 - . The Aircraft Identification Call Sign (AID)
 - . The Computer Identification Number (CID)
 - . The Beacon Code
 - . Positioning the trackball cursor over the data block and pressing trackball ENTER

All keyboard entries must be followed by a keyboard ENTER or a trackball ENTER to complete the command sequence.

PART I Data Link Keys

The CPDLC I HCI for DSR uses three dedicated keyboard keys and two "pick" keys in the R-CRD category selection area. The **Data Link (DL)** keyboard and pick keys are used to send some messages, delete messages, transfer eligibility, and initiate or terminate a Data Link session with an aircraft. The **Data Link Settings (DS)** pick key is used to display and modify a list of current sector Data Link settings, and to select or modify the contents of Data Link lists. The two remaining keyboard keys are used to uplink a transfer of communication message in the "held" status (*TC UP*), and to send a message contained in the menu text list (*MT UP*).

The current locations for these keys and the displays that are presented in the R-CRD category selection area when the *DL* or *DS* keys are pressed are shown in the following diagrams:



DL CATEGORY MENU

T	CRD			KEYS	CODE
RNG BRG	SIM	DL	DS	EMERG CHECK	
INT	PVD	ALT	METER LIST	POS CHECK	
UPLINK FREQUENCY			UF	F1	
RELEASE ELIGIBILITY			RE	F2	
END SESSION			ED	F4	
DELETE MESSAGE			DE	F6	
ACQUIRE ELIGIBILITY			SX	F7	
START SESSION			SD	F8	
DYSIM RESPONSE			JU	F9	
DYSIM MENU			JN	F10	
RA				MWL	
- RESPONSE AREA - (4 LINES) ACCEPTS/READOUTS					
MC				READ	
- MESSAGE COMPOSITION AREA - (6 LINES)					
- PREVIEW AREA - (2 LINES)					
- FEEDBACK AREA - (4 LINES) FOR ERROR MESSAGES					

UPLINK FREQUENCY: Sends your frequency to an aircraft.

RELEASE ELIGIBILITY: Sends eligibility to another sector that has track control.

END SESSION: Manually terminates a data link session with an aircraft.

ACQUIRE ELIGIBILITY: Transfers eligibility to your sector if you have track control.

DELETE MESSAGE: Deletes a transaction shown in the status list.

START SESSION: Manually initiates a data link session with an aircraft.

DYSIM RESPONSE: Training function.

DYSIM MENU: Training function.

DS DISPLAY

T	CRD	KEYS	CODE
RNG BRG	SIM	DL	DS EMERG CHECK
INT	PVD	ALT	METER LIST POS CHECK
<p>SVCS ON</p> <p style="padding-left: 40px;">IC AS MT TC</p> <p>SECTOR DL DS ON</p> <p>AUTO TOC AT OFF</p> <p>MT DISPLAY MT ON</p> <p>MT SUPR/DISP MS</p> <p>SL DISPLAY SL ON</p> <p>SL SVCS SUPR SV</p> <p style="padding-left: 40px;">MT AS</p> <p>SL STATES SUPR SZ</p> <p style="padding-left: 40px;">WIL</p>			
RA			MWL
- RESPONSE AREA - (4 LINES) ACCEPTS/READOUTS			
MC			READ
- MESSAGE COMPOSITION AREA - (6 LINES)			
- PREVIEW AREA - (2 LINES)			
- FEEDBACK AREA - (4 LINES) FOR ERROR MESSAGES			

SVCS ON: Shows those CPDLC I Services that are on for the facility.

SECTOR DL: Indicates whether CPDLC is turned ON or OFF for the sector.

AUTO TOC: Indicates whether the automatic TOC mode is ON or OFF.

MT DISPLAY: Indicates whether the Menu Text List is ON or OFF at the sector.

MT SUPR/DISPLAY: A cue to the two letter Host command (MS) used to display/suppress individual menu items.

SL DISPLAY: Indicates whether the Status List is ON or OFF at the sector.

SL SVCS SUPR: Shows the types of messages (services) that are suppressed from the Status List.

SL STATES SUPR: Shows the transaction states during which a message will be suppressed from the Status List.

CPDLC I Key Evaluation

Questions:

1. Are the locations of the Data Link keys on the keyboard (*DL*, *MT UP*, *TC UP*) and in the R-CRD "pick" area (*DL*, *DS*) acceptable for the functions that they serve?
2. Are the abbreviations used to label the Data Link keys meaningful and not susceptible to confusion with other key designations used in DSR?
3. Are the Data Link functions appropriately grouped under the *DL* and *DS* keys?
4. Are the items shown on the R-CRD when the *DL* and *DS* keys are pressed unambiguous and do they adequately indicate the functions that they will perform?

Overall Evaluation of Data Link keys:

Answer A. and B. Below

A. CPDLC I

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I –
NO CHANGES ARE NEEDED FOR LIMITED DEPLOYMENT AT THE
MIAMI ARTCC

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I –
THE CHANGES BELOW MUST BE IMPLEMENTED
ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT
MIAMI:

B. CPDLC IA

THE FOLLOWING CHANGES ARE NEEDED, BUT MAY BE
DEFERRED TO THE NATIONAL DEPLOYMENT OF CPDLC IA:

Part II

Status List and Full Data Block

- Function

The Full Data Block (FDB) provides unique graphic characters which indicate that an aircraft is equipped to receive Data Link messages and has an active Data Link session, and whether the observing control position is eligible to uplink messages to the aircraft. The FDB also provides limited information about the status of ongoing Data Link transaction.

The status list is a Host situation display tabular list that contains full information about the content and current status of ongoing Data Link transactions. The status list does not appear on the D position display.

- Full Data Block Equipage and Eligibility Indicators

Data Link equipage/session and eligibility are indicated by graphic characters located in the first position of the first line of the FDB. When no special character is displayed in this position the aircraft is not capable of communicating via Data Link or does not have an active Data Link session. An open diamond indicates that the aircraft is Data Link equipped and has an active session, but that the viewing sector position is ineligible to communicate with it. A filled diamond indicates that the aircraft is equipped with an active session, and that the viewing sector is eligible.

Data Link sessions with aircraft are normally established and terminated by automation. The controller can manually establish an active session with an aircraft that has logged-on to the Data Link system by entering *DL F8*, or typing "SD", followed by the FLID. A session can be terminated by entering *DL F4*, or typing "ED", followed by the FLID.

- Status List Format

The status list is identified by "SL" displayed in the header area of the list. Each line of the list contains information about one ongoing transaction. A line has three data fields displaying 1) the aircraft identification, 2) an abbreviated version of the content of the uplinked message, and 3) and an indication of the current status of the transaction. For example, "UAL172 123.125 SNT" would indicate that the controller had uplinked a message to switch radio frequencies to UAL 172 and that the message is in the sent status.

- Status List Abbreviations of Transaction Status

The third field of a status line presents the following abbreviations to indicate the current status of the transaction:

"SNT" - Sent: A controller input or system event has initiated the uplink

"HLD" - Held: A transfer of communication message containing the radio frequency of a new airspace sector, which the aircraft will enter, has been prepared and is ready for uplink when the sending controller makes an appropriate input.

"ROG" - Roger

"AFF" - Affirmative

"WIL" - Wilco: The system has received a downlink from the flight deck indicating that the pilot has received the message / agrees with / or will comply with the uplinked message.

"NEG" - Negative

"UNA" - Unable: The system has received a downlink from the flight deck indicating that the pilot has received the uplinked message, but does not agree with / is unable to comply.

"SBY" - Standby: The system has received a downlink from the flight deck indicating that the pilot has received the uplinked message and will subsequently reply with a positive or negative response.

"TIM" - Time Out: A timer initiated when the uplinked message was sent has expired. This is an adaptable time parameter nominally set at 40 seconds. The time out status is an indication to the controller of an unusually lengthy delay for receipt of a response from the aircraft. The transaction remains open, and a subsequent response will be accepted by the system.

"FAI" - Failed: Indicates that the Data Link session with the intended receiving aircraft has been aborted. The transaction is closed.

"ERR" - Error: Indicates that an application error has occurred in attempting to send the message. If the data field of the status list entry indicates "local error" the message has not been received by the pilot. If any other message appears in the data field, the

message may, or may not, have been received by the pilot. The ERR status closes the transaction and prevents a pilot response.

All states that close a transaction with a positive response (ROG, WIL, AFF) will delete the relevant line on the status list after an adjustable time parameter (nominally 6 seconds) has expired. Messages in any other transaction state must be manually deleted using inputs described in succeeding sections of this booklet.

- Full Data Block Indications for CPDLC I Services and Status

FDB indicators are correlated with the status list indicators, but vary depending upon the service involved. They are described in detail under succeeding sections devoted to each service.

- Inputs to Move the Status List

The status list can be moved to any position on the situation display by pressing PVD "L", slewing to the desired position, and pressing the trackball ENTER key.

- Inputs to Suppress or Retrieve the Status List

The status list can be suppressed by typing "SL OFF" (or *DS keyboard enter "SL OFF"*). The list is retrieved to the situation display by typing "SL ON" (or *DS keyboard enter "SL ON"*). These entries cannot be made from the D position.

- Selecting Message Types for Display in the Status List

The status list will display information on all four types of messages included in CPDLC I. However, the Radar controller can selectively suppress status list content by message category. The following table presents the commands used to selectively suppress and retrieve each message type.

Transfer of Communication	"SV TC OFF" or "SV TC ON"
Menu Text	"SV MT OFF" or "SV MT ON"

Altimeter Setting	"SV AS OFF" or "SV AS ON"
All Message Types	"SV OFF" or "SV ON"

It is also possible to display or suppress multiple message types in a single command (e.g. SV "TC MT OFF"). Note that pressing *DS keyboard enter* will display the Data Link settings and cue these commands for the controller.

Any transaction that results in a negative response or a TIM will be automatically forced to appear in the status list even if that message type is suppressed.

- Selecting Message States for Display in the Status List

The Radar controller also can determine the messages that will appear in the status list by their respective states. The following table presents the commands used to selectively suppress and retrieve the display of messages in five states. Messages with any other status cannot be suppressed.

SENT	"SZ SNT OFF" or "SZ SNT ON"
ROGER	"SZ ROG OFF" or "SZ ROG ON"
WILCO	"SZ WIL OFF" or "SZ WIL ON"
AFFIRMATIVE	"SZ AFF OFF" or "SZ AFF ON"

Note that pressing *DS keyboard enter* will display the Data Link settings and cue these commands for the controller.

Full Data Block and Status List Evaluation

Questions:

- 1. Do the Full Data Block symbols provide unambiguous information regarding Data Link equipage/active session and eligibility?**

- 2. Are the transaction status abbreviations (SNT etc.) used in the status list sufficiently clear and easy to understand?**

- 3. The "abnormal" status indications (NEG, UNA, FAI, ERR, TIM) are emphasized in the status list. Do you prefer "blinking" or color coding for this emphasis?**

- 4. Does the design provide an adequate capability to control (filter) the contents of the status list (i.e. by message type and status)?**

Overall Evaluation of Full Data Block and Status List Displays/Inputs:

Answer A. and B. Below

A. CPDLC I

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I –
NO CHANGES ARE NEEDED FOR LIMITED DEPLOYMENT
AT THE MIAMI ARTCC

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I –
THE CHANGES BELOW MUST BE IMPLEMENTED
ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT
MIAMI:

B. CPDLC IA

THE FOLLOWING CHANGES ARE NEEDED, BUT MAY BE
DEFERRED TO THE NATIONAL DEPLOYMENT OF CPDLC IA:

Part III

Transfer of Communication (TOC)

- Function

The Data Link transfer of communication message is automatically prepared when the receiving controller accepts a sector handoff for an equipped aircraft. The sending controller has the option to send the new frequency automatically when the handoff is accepted, or to send the message manually at a later time.

- Inputs to Set the Transfer of Communication Mode

Transfer of communication can be set to the automatic mode by typing "AT ON" (or *DS keyboard enter* "AT ON"). The manual mode is selected by typing "AT OFF".

The selected mode for TOC is shown in a banner on the situation display.

- Automatic and Manual Send Inputs

When in the automatic mode, the transfer of communication message will uplink the default frequency for the receiving sector with no additional action by the sending controller when the receiving sector accepts the handoff.

When in the manual mode, acceptance of the handoff will store the message for later transmission. The message will appear in the status list in the "HLD" status. The controller can send the message by a trackball slew/ENTER to the "dot" preceding the appropriate line in the status list or by pressing the *TC UP* key followed by the FLID, or by typing "UH" followed by the FLID.

- Changing the Default Frequency

Frequencies other than the primary default frequency for the receiving sector can be sent when using CPDLC for the transfer of communication. When making the entries to handoff the aircraft, typing "U" after the sector number will substitute a predefined alternate frequency (e.g. "22 U TWA254"). Typing a numeric radio frequency value in the same position will send that frequency if adapted for the facility.

- Status List and Full Data Block Displays on Transfer of Communication

The status list entry for a transfer of communication transaction presents the AID, the uplinked frequency, and the current transaction status message. When in a manual mode, the "HLD" status message is displayed until the controller completes the slew action or keyboard to send the message. In the automatic mode, the status line appears in the "SNT" state immediately after acceptance of the handoff.

In either mode of operation, when the transfer of communication message is sent, a "lightning bolt" symbol replaces the Data Link equipage/eligibility indicator in the first position of the first line of the Full Data Block. This symbol will appear at all sectors displaying the aircraft's FDB. When the wilco is received from the flight deck, the "lightning bolt" symbol is replaced by the filled diamond in the receiving sector and by the open diamond in all other sectors.

In an interfacility transfer of communication, the receiving sector will display the filled diamond and all Data Link eligibility symbology will be removed from sectors in the sending facility.

- Unable and Time Out Displays for Transfer of Communication and Controller Responses.

If the flight deck responds to a transfer of communication message with an unable, "UNA" is displayed in the status field of the status list. If the flight deck fails to downlink a response within 40 seconds (adaptable), "TIM" is displayed in the status field.

The unable conditions also will cause the "lightning bolt" symbol in the first position of the first line of the sending controller's Full Data Block to revert to the filled diamond symbol indicating that Data Link eligibility remains at the sending sector. All other sectors will display the open diamond.

- Deleting Transfer of Communication Transactions

The controller can close the transaction and delete "HLD", "UNA", "ERR", or "FAI" indicators by typing *DL F6* "TC" and the FLID or "DE TC" and the FLID. If the controller chooses to delete a transaction in the "SNT", "SBY" or "TIM" states "/OK" must be included in the command sequence prior to "TC" (e.g. *DL F6* "/OK TC USA219").

A transaction can also be deleted by eliminating "TC" in the command and using the trackball to select the dot preceding the appropriate line in the status list.

- Sending an Automatic Transfer of Communication When in Manual Mode

While working in the manual mode, the controller can selectively choose to send the message automatically to an individual aircraft by adding a single keystroke to the normal sequence used to offer a handoff.

The transfer of communication message will be sent automatically upon handoff acceptance if the controller offers the handoff by typing the two-digit receiving sector number, "S", and the FLID (e.g. "22 S USA435"). Alternate frequency options may be included in the command. Only one aircraft may be designated in the message. Adding the "S" to a single handoff command will not affect other subsequent aircraft handoffs, and the selected mode will remain manual.

- Holding a Transfer of Communication When in Automatic

While working in the automatic mode, the controller can selectively choose to hold the message for an individual aircraft by adding a single keystroke to the normal sequence used to offer a handoff.

The transfer of communication message will be put into the held status upon handoff acceptance if the controller offers the handoff by typing the two-digit receiving sector number, "I", and the FLID (e.g. "22 I USA435"). Alternate frequency options may be included in the command. Only one aircraft may be designated in the message. Adding the "I" to a single handoff command will not affect other subsequent aircraft handoffs, and the selected mode will remain automatic.

- Acquiring Data Link Eligibility Without a Handoff

If a controller has track control for an aircraft, Data Link eligibility can be acquired from another sector in the absence of a completed handoff by typing *DL F7* or "SX", followed by the FLID. This action does not uplink the acquiring sector's radio frequency to the aircraft.

Track control and Data Link eligibility can be acquired from another sector in the absence of a handoff with a single input by typing */OK D* and the FLID.

- Sending a Radio Frequency to an Aircraft Without a Handoff

A controller who has acquired Data Link eligibility in the absence of a handoff can send his/her sector's radio frequency to the aircraft by typing *DL F1* or "UF", followed by the FLID. Note that as the default function, *F1* can be eliminated from the command sequence.

Frequencies other than the primary default frequency for the sector can be substituted. Typing "UF U" or *DL F1* "U", followed by the FLID will substitute a predefined alternate frequency. Typing a numeric radio frequency value, rather than "U", will send that frequency if adapted for the facility.

When a frequency is sent in this manner, the message will instruct the pilot to "monitor" the new frequency. If "C" is inserted, the message will instruct the pilot to "contact" the controller on the new frequency (e.g. "UF C NWA899").

- **Initiating a Handoff Without Preparing a Transfer of Communication Message**

An aircraft with an ongoing Data Link session can be handed off without preparing or sending a transfer of communication message by typing the receiving sector's number, "O" and the FLID (e.g. "22 O USA219").

- **Forwarding Data Link Eligibility when CPDLC Transfer of Communication is Off**

A controller who has turned Data Link off at his sector, or who elects not to use Data Link to accomplish the transfer of communications, must forward eligibility to the next sector. After handing off an aircraft and instructing the aircrew to contact the next sector via voice radio, the controller will forward eligibility to the sector with track control by typing *DL F2* or "RL", followed by the FLID. (NOTE: two-letter command in Test Bed is "RE" -- change to "RL" is pending)

Transfer of Communication Evaluation

Questions:

- 1. Are the available input options for sending a "held" transfer of communication message adequate for the R controller? D controller?**
- 2. Are the Full Data Block indicators along with the status list adequate for monitoring an ongoing transfer of communication transaction?**
- 3. Are the inputs for temporarily changing the transfer of communication mode (auto/manual) for a single aircraft acceptable?**
- 4. Are the inputs used to "steal" Data Link eligibility acceptable?**
- 5. Are the inputs used to send a voice radio frequency in the absence of a hand off acceptable?**
- 6. Will the options to substitute an alternate frequency in the hand off message ("U", typed frequency) and to inhibit the preparation of a TOC message ("O") adequately support the controller's operational requirements?**

7. Are the inputs required for releasing eligibility when a controller has Data Link "off" at the sector acceptable ?

Overall Evaluation of Transfer of Communication Displays/Inputs:

Answer A. and B. Below

A. CPDLC I

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I –
NO CHANGES ARE NEEDED FOR LIMITED DEPLOYMENT
AT THE MIAMI ARTCC

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I –
THE CHANGES BELOW MUST BE IMPLEMENTED
ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT
MIAMI:

B. CPDLC IA

THE FOLLOWING CHANGES ARE NEEDED, BUT MAY BE
DEFERRED TO THE NATIONAL DEPLOYMENT OF CPDLC IA:

Part IV

Initial Contact (IC)

- Function

This service substitutes the initial radio call from the flight deck after a transfer of communication with a downlink report of assigned altitude. Under normal conditions, the initial contact procedure is automatic and transparent, and requires no controller interaction.

- Initial Contact Procedure

An assigned altitude request message is automatically appended to the radio frequency assignment message that is uplinked during transfer of communication. The flight deck responds to the transfer of communication uplink by downlinking a wilco along with a report of assigned altitude to the receiving controller.

Receipt of the wilco response transfers Data Link eligibility to the receiving sector. In addition, the reported assigned altitude is automatically checked against the aircraft's assigned altitude, interim altitude, or adapted altitude recorded in the NAS database. If the aircraft's reported downlinked assigned altitude matches the database value, nothing is displayed at the sending or receiving sectors, and no additional controller action is required.

Note that the transfer of communication message will normally instruct the pilot to "monitor" the new frequency. If the new sector is not equipped for Data Link, it will instruct the pilot to "contact" the controller at the new frequency and no altitude request will be sent.

- Discrepancy Between Reported and Assigned Altitudes

If the reported assigned altitude fails to match the assigned or interim altitude contained in the NAS database, the downlinked value followed by "I" will appear the first four positions of the second line of the Full Data Block. This will timeshare every 1.5 seconds with the database value followed by the altitude conformance indicator. If the Mode C altitude had been displayed in this field when the timesharing began, the Mode C altitude will be shifted to the right of the second line to make it continuously viewable.

In addition to the FDB display, a status list entry will be created displaying the AID, the NAS data base altitude, and the downlinked altitude. The down linked

altitude will be right justified in the data field of the status list. The status field will show "/IIC" (e.g. "TWA515 240 340/IIC").

The Data Link eligible receiving controller with track control can resolve the mismatch by contacting the flight deck via voice radio. The error displays may be cleared by deleting the IC status list entry (*DL F6* "IC" and the FLID or "DE IC" and the FLID).

Initial Contact Evaluation

Questions:

1. Are the timeshared FDB display and the status list indicator sufficient to alert the controller of an initial contact downlink of an altitude that fails to match the NAS database?
2. Are the options for deleting an IC mismatch acceptable?

Overall Evaluation of Initial Contact Displays/Inputs:

Answer A. and B. Below

A. CPDLC I

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I –
NO CHANGES ARE NEEDED FOR LIMITED DEPLOYMENT
AT THE MIAMI ARTCC

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I –
THE CHANGES BELOW MUST BE IMPLEMENTED
ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT
MIAMI:

B. CPDLC IA

THE FOLLOWING CHANGES ARE NEEDED, BUT MAY BE
DEFERRED TO THE NATIONAL DEPLOYMENT OF CPDLC IA:

Part V

Menu Text

- Function

The Menu Text function permits the controller to uplink non-safety critical messages by selecting them from a predefined menu list. Menus can be tailored to meet the specific requirements of individual airspace sectors.

- Menu Format

The menu is a Host situation display tabular list identified by "ML" in the header area of the list. Each line of the menu contains one message preceded by an identifying menu referent used to select the message. The menu referent must begin with an alphabetic character. Up to ten messages can be displayed in the menu list. A sample menu is shown below:

A	WRI ILS OUT RWY 6 / 24
B	BAD WEATHER WARN
MIC	CHECK STUCK MIC
CALL	CALL COMPANY

- Inputs to Send a Menu Text Message

To send a menu text message, press the *MT UP* key (or type "UM"), the menu item referent, and the FLID (e.g. *MT UP* "A USA456").

The message can be sent to all aircraft that are Data Link eligible for the sector by substituting " *ALL " for the FLID in the keyboard command.

- Full Data Block and Status List Displays on Menu Text Uplink

When a menu text message is uplinked, an up-arrow symbol replaces the filled diamond in the first position of the first line of the Full Data Block at all positions displaying the Full Data Block. The up-arrow is removed when the message receives the appropriate positive or negative response from the flight deck or when it is deleted from the status list.

For all messages sent from the menu, the status list will display the AID followed by the menu item referent, and the current status of the transaction (e.g. "AA231 CALL SNT"). The status list line is deleted when the appropriate positive or negative response from the flight deck is received, or when the controller deletes it from the status list.

When a message is sent to all aircraft, a single line is created in the status list with "ALL" appearing the FLID field. The status line is deleted when all of the aircraft respond with the appropriate positive response. A separate line is created in the status list for each negative aircraft response to an all message, or if a transmission error occurs ("ERR", "FAI").

- Deleting Menu Text Transactions

The controller can close the transaction and delete "UNA", "ERR", "FAI", or "NEG" indicators by typing *DL F6* "MT" and the FLID or "DE MT" and the FLID. If the controller chooses to delete a transaction in the "SND", "SBY" or "TIM" states, "/OK" must be included in the command sequence prior to "MT" (e.g. *DL F6* "MT /OK USA219"). The transaction can also be deleted by eliminating the "MT" and FLID in the command and using the trackball to select the dot preceding the appropriate line in the status list. If the trackball is not used for this command, all MT transactions for the aircraft that are displayed in the status list will be deleted.

- Controlling Menu Text List Content

A menu build function will be used by supervisory personnel to create sector-tailored menus. However, the controller will have the capability to determine whether the menu list will be displayed, and to selectively display or suppress individual items. Messages continue to be available for uplink when suppressed from the display.

The menu list can be suppressed by typing "MT OFF" (or *DS keyboard enter* "MT OFF"). The list is retrieved to the situation display by typing "MT ON" (or *DS keyboard enter* "MT ON"). These entries cannot be made from the D position.

Suppression of the individual messages in the menu is accomplished by typing "*MS menu referent* OFF". A message can be retrieved by substituting "ON" in the command sequence.

Up to five messages can be suppressed or retrieved in a single command by separating the menu referents with spaces.

It should be noted that sectors may be assigned two types of menu messages. Permanent messages intended for routine use on a daily basis may be suppressed from the list. Procedures will not permit suppression of temporary messages created for non-routine special situations.

- Inputs to Move the Menu

The menu text list can be moved to any position on the situation display by pressing *PVD* "A", slewing to the desired position, and pressing the trackball PICK ENTER key.

Menu Text Evaluation

Questions:

1. Are the available input options for sending a menu text message adequate for the R controller? D controller?
2. Are the FDB indicators along with the status list adequate for monitoring an ongoing menu text transaction?
3. Are the options for suppressing/retrieving items in the menu text list acceptable?

Overall Evaluation of Menu Text Displays/Inputs:

Answer A. and B. Below

A. CPDLC I

_____ THE DESIGN IS ACCEPTABLE FOR CPDLC I –
NO CHANGES ARE NEEDED FOR LIMITED DEPLOYMENT
AT THE MIAMI ARTCC

_____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I –
THE CHANGES BELOW MUST BE IMPLEMENTED
ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT
MIAMI:

B. CPDLC IA

THE FOLLOWING CHANGES ARE NEEDED, BUT MAY BE
DEFERRED TO THE NATIONAL DEPLOYMENT OF CPDLC IA:

Part VI

Altimeter Setting (AS)

- Function

This Data Link message uplinks an altimeter setting to the flight deck. Normally, the uplink will be accomplished automatically in accordance with procedures and directives. An altimeter setting can also be manually uplinked by the controller.

- Manual Uplink of Altimeter Setting

An altimeter setting can be manually uplinked by pressing *CRD*, typing the designator for the station providing the local altimeter setting, "S" and the FLID.

- Full Data Block and Status List Displays for Altimeter Setting Messages

When an altimeter setting message is uplinked either automatically or manually, an up-arrow symbol replaces the hourglass in the first position of the first line of the Full Data Block at all positions displaying the FDB. The up-arrow is removed when the message receives a "ROG" or "UNA", or is deleted from the status list.

For all altimeter messages, the status list will display the AID followed by the station designator and the altimeter setting, and the current status of the transaction (e.g. "AAL231 DCA 2997 SNT"). The status list line is deleted when a "ROG" is received. Messages in any other transaction state must be manually deleted.

- Deleting Altimeter Setting Transactions

The controller can close the transaction and delete "UNA" or "ERR" indicators by typing *DL F6* "AS" and the FLID or "DE AS" and the FLID. If the controller chooses to delete a transaction in the "SND", "SBY" or "TIM" state "/OK" must be included in the command sequence prior to "AS" (e.g. *DL F6* "/OK AS USA219"). The transaction can also be deleted by eliminating the "AS" and FLID in the command and using the trackball to select the line in the status list. If the trackball is not used for this command, all AS transactions for the aircraft that are displayed in the status list will be deleted.

Altimeter Setting Evaluation

Questions:

1. Are the inputs for sending an altimeter setting message adequate for the R controller? D controller?
2. Are the Full Data Block indicators along with the status list adequate for monitoring an ongoing altimeter setting transaction?
3. Do you feel that the Full Data Block and Status List indicators are adequate for detecting an error or failure in an altimeter setting message that has been sent automatically?

**Overall Evaluation of Altimeter Setting Displays/Inputs:
Answer A. and B. Below**

A. CPDLC I

- _____ THE DESIGN IS ACCEPTABLE FOR CPDLC I –
NO CHANGES ARE NEEDED FOR LIMITED DEPLOYMENT
AT THE MIAMI ARTCC

- _____ THE DESIGN IS UNACCEPTABLE FOR CPDLC I –
THE CHANGES BELOW MUST BE IMPLEMENTED
ASSURE SAFETY AND OPERATIONAL ACCEPTANCE AT
MIAMI:

B. CPDLC IA

THE FOLLOWING CHANGES ARE NEEDED, BUT MAY BE
DEFERRED TO THE NATIONAL DEPLOYMENT OF CPDLC IA:

GENERAL QUESTIONS

1. Are the inputs and displays for accomplishing functions under the Data Link Settings menu acceptable for managing the contents of the Menu Text List? Status List?
2. Do you feel that the Data Link turn around times (elapsed time from sending a message to receiving a pilot response) that you experienced in the simulations are short enough to enable effective use of CPDLC I by controllers in the field?
3. In future builds, would a "repeater" of the Status List at the DSR D position display be desirable?
4. Do you feel that the training and DYSIM exercises on DSR and Data Link that you received for this study provided you with an adequate basis for evaluating CPDLC I?
5. In the current design, the D-Side keyboard does not include the *DL* and *DS* keys. Where accessible to the D-Side, the functionality provided

under these keys must be accessed using two-letter commands. In a future build, do you feel that it would be useful to provide these keys on the D-Side keyboard or in a category "pick" area on the D-CRD ?

**CPDLC IA
DISPLAY SYSTEM REPLACEMENT (DSR)**

HUMAN-COMPUTER INTERFACE

CONTROLLER DESIGN REVIEW BOOKLET

This booklet contains a series of questions that will permit you to independently review and evaluate the CPDLC IA Human-Computer Interface (HCI) that will be implemented on the DSR. The goals of this review are to identify those aspects of the HCI that will be acceptable as presented, or will require modification prior to fielding.

Please answer all of the questions in this booklet and carefully record your comments and any recommendations for design changes. Please explain your reasons for suggesting any changes.

Reviewer's Name _____

Instructions

This booklet is divided into 5 parts that will permit you to make a detailed evaluation of the added functionality provided by CPDLC IA and of the controller interface design. Each part begins with a design description. Read these descriptions carefully before answering the associated questions and recording your comments.

NOTES ON CONVENTIONS USED IN THE DESIGN DESCRIPTIONS

- Data as shown in a display or entered on the keyboard are presented in quotation marks. When spaces are required, they are included within the quotation marks. The quotation marks are not part of the display or entry.
- All spaces included within quotation marks for keyboard entries are mandatory. For example, "MT ON" should be interpreted as typing MT, a space, and ON.
- Input commands printed in bold italics refer to a DSR keyboard category, soft function, or hard function key, or a "key" in the R-CRD Category Selection Area (e.g. *DL*, *DS*, *F1*).
- Two trackball keys are used. Trackball ENTER (middle key) is used to complete a command sequence. Trackball SELECT (left key) is used to identify an item in the R-CRD text area or the status list and to identify lists for moving them on the display.
- FLID refers to any NAS command for identifying a flight including:
 - . The Aircraft Identification Call Sign (AID)
 - . The Computer Identification Number (CID)
 - . The Beacon Code
 - . Positioning the trackball cursor over the data block and pressing trackball ENTER

All keyboard entries must be followed by a keyboard ENTER or a trackball ENTER to complete the command sequence.

PART I

Altitude Clearances

- Function

This service permits the controller to uplink an assigned or interim altitude by manually entering a three digit altitude value (hundreds of feet). A message that receives a wilco downlink from the flight deck automatically updates the NAS database and/or the FDB, as appropriate.

- Inputs to Send an Altitude Assignment

Assigned altitudes can be uplinked using one of two alternative methods. In the first method the controller modifies the normal Host command used to amend an assigned altitude in the NAS database. To update the system and send the message by Data Link, an "S" is inserted between the altitude value and the FLID in the command (e.g. *ALT "370 S UAL123" ENTER*).

The second uses the menu text function with a reserved menu referent ("A"). Typing *MT UP "A"* the altitude and the FLID will uplink the new altitude and update NAS (e.g. *MT UP "A 370 AAL321" ENTER*).

- Full Data Block and Status List Displays on Altitude Uplink

When the assigned altitude send command is entered, the up arrow appears in the first line of the FDB and the new altitude value followed by an "S" appears in the first four positions of the second line of the FDB. This timeshares with the display of the previous assigned altitude and conformance indicator.

Upon receipt of a wilco response from the flight deck, the "S" is replaced by a "W". The timesharing continues for six seconds, after which the new assigned altitude is shown with the appropriate conformance indicator.

During the transaction, the status list displays the AID, the altitude value and the current status abbreviation. Upon receipt of a wilco, "WIL" is displayed for six seconds, after which the entire status list line is automatically deleted.

- Inputs to Send an Interim Altitude

Interim altitudes can also be uplinked using one of two alternative methods. In the first method the controller modifies the normal Host command used to amend an altitude in the FDB. To update the FDB and send the message by Data Link, an "S"

is inserted between the altitude value and the FLID in the command (e.g. *INT "370 S UAL123" ENTER*).

The second uses the menu text function with a reserved menu referent ("T"). Typing *MT UP "T"* the altitude and the FLID will uplink the new altitude and update the FDB (e.g. *MT UP "T 370 AAL321" ENTER*).

- Full Data Block and Status List Displays on Interim Altitude Uplink

When the interim altitude send command is entered, the up arrow appears in the first line of the FDB and the interim altitude value followed by an "S" appears in the first two fields of the second line of the FDB. This timeshares with the display of the current assigned altitude and conformance indicator. Upon receipt of a wilco response from the flight deck, the "S" is replaced by a "W". The timesharing continues for six seconds, after which the accepted interim altitude is shown with the normal "T" conformance indicator.

During the transaction, the status list displays the AID, the interim altitude value and the current status abbreviation. Upon receipt of a wilco, "WIL" is displayed for six seconds, after which the entire status list line is automatically deleted.

- Unable and Time Out Displays for Assigned and Interim Altitudes and Controller Responses.

If the flight deck responds to an altitude clearance with an unable, "UNA" is displayed in the status field of the status list. If the flight deck fails to downlink a response within 40 seconds, "TIM" is displayed in the status field. In either case, the controller can close the transaction and delete all "UNA" or "TIM" indicators by the same means used for deleting CPDLC I messages.

Altitude Clearances Evaluation

Questions:

1. Are the two methods for sending an altitude (piggyback and reserved menu referent) acceptable?

2. Does altitude timesharing provide adequate feedback on the message sent and its status?

3. Would the Status List alone be sufficient for providing this feedback?

Overall Assessment of Altitude Clearance Displays/Inputs:

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE DESIRABLE OR NEEDED

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE NEEDED BUT THE FOLLOWING
MODIFICATIONS OR IMPROVEMENTS WOULD BE
DESIRABLE:

_____ THE DESIGN AS DESCRIBED HERE IS UNACCEPTABLE—
THE FOLLOWING CHANGES MUST BE MADE:

Part II

Speed and Heading Clearances

- Function

In addition to altitudes, CPDLC provides the controller with the ability to manually uplink speed and heading clearances.

- Speed Clearances

The controller can assign a new manually-entered speed through the menu text function using reserved menu referents ("K" or "M"). Typing *MT UP "K"* the three digit speed and the FLID will send a speed in KNOTS (e.g. *MT UP "K 160 USA345" ENTER*). Typing *MT UP "M"* the three digit speed and the FLID will send a speed in MACH (e.g. *MT UP "M 003 AAL654" ENTER*).

- Full Data Block and Status List Displays on Speed Clearance Uplink

When the speed send command is entered, the up arrow appears in the first line of the FDB. During the transaction, the status list displays the AID, the speed value in knots or mach, and the current status abbreviation. Upon receipt of a wilco, "WIL" is displayed for six seconds, after which the entire status list line is automatically deleted.

- Heading Clearances

The controller can assign a new manually-entered heading through the menu text function using a reserved menu referent ("H"). Typing *MT UP "H"* the three digit compass direction and the FLID will instruct the pilot to turn to the new cleared heading (e.g. *MT UP " H 090 USA345" ENTER*.)

- Full Data Block and Status List Displays on Heading Clearance Uplink

When the heading send command is entered, the up arrow appears in the first line of the FDB. During the transaction, the status list displays the AID, the new heading, and the current status abbreviation. Upon receipt of a wilco, "WIL" is displayed for six seconds, after which the entire status list line is automatically deleted.

Speed and Heading Clearance Evaluation

Questions:

1. In addition to the status list, CPDLC IA can also provide a Full Data Block indication of the status and contents of Speed and Heading clearances. Do you feel that the timesharing approach demonstrated during the practice exercises was acceptable?

Overall Assessment of Speed and Heading Clearance Displays/Inputs:

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE DESIRABLE OR NEEDED

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE NEEDED BUT THE FOLLOWING
MODIFICATIONS OR IMPROVEMENTS WOULD BE
DESIRABLE:

_____ THE DESIGN AS DESCRIBED HERE IS UNACCEPTABLE—
THE FOLLOWING CHANGES MUST BE MADE:

Part III

Menu Text

- Function

CPDLC IA provides the controller with an ability to send commonly-used clearances by selecting them from a predefined menu list. Menus can be tailored to meet the specific requirements of individual airspace sectors.

- Menu Format

The menu is a Host situation display tabular list identified by "ML" in the header area of the list. Each line of the menu contains one message preceded by an identifying menu referent used to select the message. The menu referent must begin with an alphabetic character. Up to ten messages can be displayed in the menu list.

- Inputs to Send a Menu Text Message

To send a menu text message, press the *MT UP* key (or type "UM"), the menu item referent, and the FLID (e.g. *MT UP "C USA456"*). Messages can also be sent by using the trackball to PICK the dot in front of the desired menu entry, slewing to the aircraft position symbol, and pressing PICK ENTER.

The message can be sent to all aircraft that are Data Link eligible for the sector by substituting " *ALL " for the FLID in the keyboard command.

In CPDLC IA, menu items containing altitude clearances can be designed to update the NAS database. Items beginning with an asterisk (*) will up date the database when sent.

CPDLC IA also allows menu items to have variable fields that can be altered by the controller on any uplink. These fields are bounded by "slashes" (e.g. *.B * X ULLMAN / T100 / K250*). To change the altitude to 20,000 ft. for a single uplink in the preceding example, the controller would type *MT UP "B 200 FLID"*.

- Full Data Block and Status List Displays on Menu Text Uplink

When a menu text message is uplinked, an up-arrow symbol replaces the filled diamond in the first position of the first line of the Full Data Block at all positions displaying the Full Data Block. The up-arrow is removed when the message

receives the appropriate positive or negative response from the flight deck or when it is deleted from the status list.

For all messages sent from the menu, the status list will display the AID followed by the menu item referent, and the current status of the transaction (e.g. "AA231 C SNT"). The status list line is deleted when the appropriate positive or negative response from the flight deck is received, or when it is deleted from the status list.

When a message is sent to all aircraft, a single line is created in the status list with "ALL" appearing the FLID field. The status line is deleted when all of the aircraft respond with the appropriate positive response. A separate line is created in the status list for each negative aircraft response to an all message, or if a transmission error occurs ("ERR", "FAI").

- Controlling Menu Text List Content

A menu build function will be used by supervisory personnel to create sector-tailored menus. However, the controller will have the capability to determine whether the menu list will be displayed, and to selectively display or suppress individual items. Messages continue to be available for uplink when suppressed from the display.

The menu list can be suppressed by typing "MT OFF" or (*DS keyboard enter "MT OFF"*). The list is retrieved to the situation display by typing "MT ON" (or *DS keyboard enter "MT ON"*). These entries cannot be made from the D position.

Suppression of the individual messages in the menu is accomplished by typing "*MS menu referent OFF*" (or *DS keyboard enter "MS menu referent OFF"*). A message can be retrieved by substituting "ON" in the command sequence.

Up to five messages can be suppressed or retrieved in a single command by separating the menu referents with spaces.

It should be noted that sectors may be assigned two types of menu messages. Permanent messages intended for routine use on a daily basis may be suppressed from the list. Procedures will not permit suppression of temporary messages created for non-routine special situations.

- Inputs to Move the Menu

The menu text list can be moved to any position on the situation display by pressing *PVD* "A", slewing to the desired position, and pressing the trackball PICK ENTER key.

Menu Text Evaluation

Questions:

1. Are the inputs used to change the data in a variable field menu text message acceptable?
2. Is the asterisk an effective indicator of menu text messages that will update the NAS database/FDB?

Overall Assessment of Menu Text Displays/Inputs:

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE DESIRABLE OR NEEDED

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE NEEDED BUT THE FOLLOWING
MODIFICATIONS OR IMPROVEMENTS WOULD BE
DESIRABLE:

_____ THE DESIGN AS DESCRIBED HERE IS UNACCEPTABLE—
THE FOLLOWING CHANGES MUST BE MADE:

Part IV

Route Assignment

- Function

This service gives a controller the ability to uplink route changes to the flight deck.

- Inputs to Uplink a Route Change

Route change clearances containing a single fix can be uplinked by modifying the commands currently used to modify an aircraft's route in the flight plan. To change the flight plan and uplink the clearance type: "QU *fix* S FLID" or *RTE* "*fix* S FLID".

- Full Data Block and Status List Displays on Route Assignment Uplink

When a route assignment message is uplinked, an up-arrow symbol replaces the filled diamond in the first position of the first line of the FDB. The up-arrow is removed when the message receives the appropriate positive or negative response from the flight deck or when it is deleted from the status list.

For all messages the status list will display the AID followed by the abbreviated message, and the current status of the transaction (e.g. "AA231 CLRD DIRECT MIA SNT"). The status list line is deleted when the appropriate positive or negative response from the flight deck is received, or when it is deleted from the status list.

Route Assignment

Evaluation

Overall Assessment of Route Assignment Displays/Inputs:

- _____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE DESIRABLE OR NEEDED

- _____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE NEEDED BUT THE FOLLOWING
MODIFICATIONS OR IMPROVEMENTS WOULD BE
DESIRABLE:

- _____ THE DESIGN AS DESCRIBED HERE IS UNACCEPTABLE—
THE FOLLOWING CHANGES MUST BE MADE:

Part V

Altitude Request Downlinks

- Function

This service permits a pilot to downlink a request for a change in altitude. The controller may respond by accepting the request and uplinking a clearance to the desired altitude, denying the request, or by uplinking a "standby" message.

- Viewing Individual Aircraft Downlinks

When a downlink from an aircraft arrives, a down-arrow replaces the filled diamond in the full data block. To view the downlink, the controller types "DW FLID" ENTER. A downlink list for the selected aircraft will then appear on the DSR situation display. The list has a header showing the AID followed by the message(s). Each message line shows the aircraft's CID, the AID, the request, and the time of message receipt. This is followed by a pre-prepared positive message response as shown below:

```
PD
. AAL700 Down Links
. 109A  AAL700 REQ. ALT 370 2356
      CTAM FL370
. 109B  AAL700 REQ. ALT 350 2410
      CTAM FL350
```

If the aircraft has multiple open downlinks, the messages will appear in the list in chronological order of receipt. Each message CID will be annotated with an alphabetic character to indicate the order of receipt.

- Sending the Requested Altitude

If the controller elects to assign the requested altitude, typing "S" and slewing to the dot preceding the message in the downlink list (or typing "DW S CID^{letter}") will uplink the new altitude. The message is cleared from the downlink list and appears as a sent message in the status list. As in other altitude messages, an up-arrow will appear in the FDB and the uplinked altitude will timeshare with the current assigned altitude until the pilot's wilco response is received.

- Sending an Unable or Standby Response

If the controller elects not to assign the requested altitude, typing "U" and slewing to the dot preceding the message in the downlink list (or typing "DW U CID_{letter}") will send the unable response and suppress the downlink list. If the controller requires additional time to respond positively or negatively to the request, typing "Y" and slewing to the dot preceding the message in the downlink list (or typing "DW Y CID_{letter}") will send the standby response. If the controller wishes to suppress the aircraft's downlink list during the standby period, typing "DW FLID" will toggle the list off. The down-arrow will remain in the position of the Data Link symbol in the FDB until a positive or negative response is sent.

- Deleting a Downlink

A downlink request can be deleted from the list by typing "D" and slewing to the dot preceding the message in the downlink list (or typing "DW D" CID_{letter}").

- Viewing Downlinks From All Aircraft

Typing "DW" will call up a list of outstanding downlinks from all aircraft under Data Link control of the sector. The header for will display "Downlinks" followed by a list of all messages in chronological order of receipt.

- Moving a Downlink List

The downlink list can be repositioned on the display by typing *PVD* "T", slewing to the new position and pressing PICK ENTER.

Altitude Request Downlinks Evaluation

Questions:

1. Does the format of the downlink list permit controllers to easily determine which message contains the oldest/newest outstanding request for one aircraft? All aircraft?

2. Are the inputs used to respond to a downlinked request acceptable?

3. Does the design of this service adequately support processing of downlinks by the D-side?

Overall Assessment of Altitude Request Displays/Inputs:

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE DESIRABLE OR NEEDED

_____ THE DESIGN AS DESCRIBED HERE IS ACCEPTABLE –
NO CHANGES ARE NEEDED BUT THE FOLLOWING
MODIFICATIONS OR IMPROVEMENTS WOULD BE
DESIRABLE:

_____ THE DESIGN AS DESCRIBED HERE IS UNACCEPTABLE—
THE FOLLOWING CHANGES MUST BE MADE:

GENERAL QUESTIONS

1. Do you feel that the Data Link turn around times (elapsed time from sending a message to receiving a pilot response) that you experienced in the simulations are short enough to enable effective use of CPDLC 1A by controllers in the field?
2. Do you feel that a "repeater" of the Status List at the DSR D position display will be necessary for CPDLC 1A?
3. Do you feel that the D-side should have more direct access to Data Link in CPDLC 1A (e.g. *MT UP*, *TC UP*, *DL* keys)?
4. Do you feel that the training and DYSIM exercises on DSR and Data Link that you received for this study provided you with an adequate basis for evaluating CPDLC 1A?

CPDLC I DYSIM TASK CHECKLIST

To facilitate your evaluation of the CPDLC I design you should perform all tasks described on this checklist during the DYSIM exercise.

- ❑ Where possible, perform each task from both the R and D positions.
- ❑ Exercise each of the optional methods for performing the task (i.e. two-letter Host command, category/function keys, trackball).

TRANSFER OF COMMUNICATIONS	
Send TOC in manual mode	
	1. Set AUTO TOC to OFF – Type: “AT OFF” <u>or</u> DS “AT OFF”
	2. Offer hand off – Type: <i>sector number</i> FLID
After hand off acceptance, observe data block and held message in status list	
	4. Send the held TOC – Type: “UH” FLID <u>or</u> TC UP FLID <u>or</u> Slew/ENTER to dot preceding status list Entry for HLD TOC
	5. Observe data block and status list changes as message is sent and wilcoed
Send AUTO TOC to one aircraft while in the manual mode.	
	1. Offer hand off – Type: <i>sector number</i> “S” FLID
	2. After hand off acceptance, observe data block and sent message in status list
Send TOC in AUTO mode	
	1. Set AUTO TOC to ON – Type: “AT ON” <u>or</u> DS “AT ON”
	2. Offer hand off – Type: <i>sector number</i> FLID
	3. After hand off acceptance, observe data block and sent message in status list
Hold TOC for one aircraft while in the AUTO TOC mode	
	1. Offer hand off – Type: <i>sector number</i> “I” FLID
	2. After hand off acceptance, observe held message in status list
	3. Send the held TOC – Type: “UH” FLID <u>or</u> TC UP FLID <u>or</u> Slew/ENTER to dot preceding status list entry for HLD TOC
	4. Observe data block and status list changes as message is sent and wilcoed
Override the default frequency for TOC using a predefined alternate frequency	
	1. With AUTO TOC in ON or OFF mode, offer hand off – Type: <i>sector number</i> “U” FLID
	2. Observe data block and status list changes
Override the default frequency for TOC using any frequency adapted for the facility	
	1. With AUTO TOC in ON or OFF mode, offer hand off – Type: <i>sector number frequency</i> FLID
	2. Observe data block and status list changes

Initiate a hand off without preparing a TOC message	
	1. With AUTO TOC in ON or OFF mode, offer hand off – Type: <i>sector number "O" FLID</i>
ALTIMETER SETTING	
Manually uplink an altimeter setting	
	Insure that altimeter setting data is in the system – Type from D-side: <i>"AS time SEA 992"</i>
	Type: <i>CRD reporting station designator "S" FLID or</i> <i>"QD" reporting station designator "S" FLID</i>
	3. Observe data block and status list changes
MENU TEXT	
Send menu text messages to individual aircraft	
	1. Type: <i>"UM" menu referent FLID or</i> <i>MT UP menu referent FLID</i>
	2. Observe data block and status list changes
Send menu text messages to all aircraft	
	1. Type: <i>"UM" menu referent "ALL" or</i> <i>MT UP menu referent "ALL"</i>
	2. Observe status list handling of multiple responses
Reposition the menu text list on the Situation Display	
	1. Type <i>PVD "A"</i>
	2. Slew to new position
	3. Trackball ENTER
Turn the menu text list off/on	
	1. Type: <i>"MT OFF" or</i> <i>DS "MT OFF"</i>
	2. Type: <i>"MT ON" or</i> <i>DS "MT ON"</i>
Exercise the capability to suppress and redisplay individual menu text messages	
	1. Type: <i>"MS menu referent OFF" or</i> <i>DS " MS menu referent OFF"</i>
	2. Type: <i>"MS menu referent ON" or</i> <i>DS " MS menu referent ON"</i>

Suppress and display all messages in the menu text list	
	1. Type: "MS *ALL OFF" <u>or</u> <i>DS " MS *ALL OFF"</i>
	2. Type: "MS *ALL ON" <u>or</u> <i>DS F4 "**ALL ON"</i>
ERROR CONDITIONS	
Observe an initial contact (IC) mismatch error. Exercise alternative inputs to clear the error display (see facilitator).	
	1. Observe data block display of assigned altitude timesharing with the incorrect downlinked altitude followed by an "I" and the Mode C altitude
	2. Status list entry shows assigned altitude, downlinked altitude, and "IIC" as the status
	3. Clear the display – Type: "DE IC" FLID <u>or</u> <i>DL F6 IC" FLID or</i> "DE" slew/trackball ENTER to the dot preceding the appropriate entry in the status list (R-side only)
Using TOC messages, observe UNA and ERR status list displays and associated data block indications that the TOC has not been completed. Exercise alternative inputs to clear the error displays (see facilitator).	
	1. Delete all closed transactions of the selected service type for the aircraft – Type: "DE" <i>service type</i> FLID <u>or</u> <i>DL F6 service type FLID</i> Service types are: TC, MT, AS
	2. Delete only the selected transaction (R-side only): "DE" slew/trackball ENTER to the dot preceding the appropriate entry in the status list.
	Delete <u>all</u> messages in these closed, negative states: "DE FLID" <u>or</u> <i>DL F6 FLID</i> Service types are: TC, MT, AS
Using TOC messages, exercise the inputs to delete messages in an open state (SNT, TIM, SBY) (see facilitator)	
	1. DELETE ALL OPEN TRANSACTIONS OF THE SELECTED SERVICE TYPE FOR THE AIRCRAFT – TYPE: "DE /OK" <i>SERVICE TYPE</i> FLID <u>OR</u> <i>DL F6 "/OK" SERVICE TYPE FLID</i>
	2. Delete only the selected open transaction (R-side only): "DE /OK" slew trackball ENTER to the dot preceding the appropriate entry in the status list. Service types are: TC, MT, AS

SESSION AND ELIGIBILITY MANAGEMENT	
Manually establish a Data Link session with an aircraft	
	1. Type: "SD" FLID <u>or</u> <i>DL F8 FLID</i>
	2. Observe display of filled diamond in data block
Manually terminate a Data Link session with an aircraft	
	1. Type: "ED" FLID <u>or</u> <i>DL F4 FLID</i>
	2. Observe removal of filled diamond from data block
Uplink your frequency to an aircraft	
	1. Type: "UF" FLID <u>or</u> <i>DL F1 FLID</i>
	2. Observe data block and status list changes
Uplink alternate frequency to an aircraft	
	1. Type: "UF U" FLID <u>or</u> <i>DL F1 "U" FLID</i>
	2. Observe data block and status list changes
Uplink frequency to an aircraft and instruct pilot to "contact" rather than "monitor"	
	1. Type "UF C" FLID <u>or</u> <i>DL F1 "C" FLID</i>
	2. Observe data block and status list changes
Steal Data Link eligibility for an aircraft	
	1. You must have track control for this aircraft—Type: FLID "/OK"
	2. Type: "SX" FLID <u>or</u> <i>DL F7 FLID</i>
	3. Observe data block and status list displays
Steal track control and Data Link eligibility for an aircraft	
	1. Type: "/OK D" FLID
	2. Observe data block and status list displays
Release eligibility to the next sector	
	1. Type "RE" FLID <u>or</u> <i>DL F2 FLID</i>
	2. Observe eligibility shift to next sector

SECTOR SET UP	
Suppress/Display the Status List	
	1. Type: "SL OFF" <u>or</u> DS "SL OFF"
	2. Type: "SL ON" <u>or</u> DS " SL ON"
Filter the Status List by Service Type	
	1. Type "SV" service type "OFF" <u>or</u> DS " SV service type "OFF" Service types are: TC, AS, and MT
	2. Type "SV" service type "ON" <u>or</u> DS " SV service type "ON"
	3. Note that messages of service types set to "OFF" do not appear in status list UNLESS a negative status occurs (e.g. FAI, TIM, UNB)
Filter the Status List by Message State	
	1. Type: "SZ" state "OFF" <u>or</u> DS "SZ state "OFF" States eligible for filtering are: SNT (sent), ROG (roger), WIL (wilco), and AFF (affirmative)
	2. Type: "SZ" state "ON" <u>or</u> DS "SZ state "ON"
	3. Note that messages in states that are set to "OFF" do not appear in status list
Reposition the Status List on the Situation Display	
	1. PVD "L" slew/trackball ENTER

CPDLC IA DYSIM TASK CHECKLIST

To facilitate your evaluation of the CPDLC IA design you should perform all tasks described on this checklist during the DYSIM exercise.

- ❑ Where possible, perform each task from both the R and D positions.
- ❑ Exercise each of the optional methods for performing the task (i.e. two-letter Host command, category/function keys, trackball)

ALTITUDE ASSIGNMENT	
Send an Altitude Assignment	
	1. Type: <i>ALT</i> " <i>alt</i> S FLID" ENTER <u>or</u> <i>MT UP</i> " <i>A alt</i> FLID" ENTER <u>or</u> "UM A <i>alt</i> FLID" ENTER
	2. Observe up-arrow in FDB, timesharing in FDB altitude field, and Status List entry
Send an Interim Altitude	
	1. Type: <i>INT</i> " <i>alt</i> S FLID" ENTER <u>or</u> <i>MT UP</i> " <i>T alt</i> FLID" ENTER <u>or</u> "UM T <i>alt</i> FLID" ENTER
	2. Observe up-arrow in FDB, timesharing in altitude field of FDB, and Status List entry
SPEED ASSIGNMENT	
Send a Speed Clearance in Knots	
	1. Type: <i>MT UP</i> " <i>K spd</i> FLID" ENTER <u>or</u> "UM K <i>spd</i> FLID" ENTER
	2. Observe up-arrow in FDB and Status List Entry
Send a Speed Clearance in Mach	
	1. Type: <i>MT UP</i> " <i>M spd</i> FLID" ENTER <u>or</u> "UM M <i>spd</i> FLID" ENTER
	2. Observe up-arrow in FDB and Status List Entry
HEADING ASSIGNMENT	
Send a Heading	
	1. Type: <i>MT UP</i> " <i>H hdg</i> FLID" ENTER
	2. Observe up-arrow in FDB and Status List Entry
MENU TEXT	
Send a Message From the Menu	
	1. Type: <i>MT UP</i> " <i>menu referent</i> FLID" ENTER <u>or</u> "UM <i>menu referent</i> FLID" ENTER <u>or</u> Trackball PICK the menu item and trackball PICK ENTER the aircraft Position symbol
	2. Observe up-arrow in FDB and Status List Entry

Send a Message with a Variable Data Field	
	1. Select a message from the menu with a value bounded by slashes (/xxx/)
	2. Type: <i>MT UP</i> " menu referent variable field data FLID" ENTER <u>or</u> "UM menu referent variable field data FLID" ENTER <u>or</u>
	3. Observe up-arrow in FDB and Status List Entry
ROUTE ASSIGNMENT	
Send a Route Change	
	1. Type: <i>RTE fix</i> S FLID" ENTER <u>or</u> "QU <i>fix</i> S FLID" ENTER
	2. Observe up-arrow in FDB and Status List Entry

DOWNLINKS	
View a Downlink From One Aircraft (see facilitator)	
	1. Observe down-arrow in FDB
	2. Type "DW FLID" ENTER
	3. Observe Downlink List for the aircraft.
Move the Downlink List	
	1. Type: <i>PVD</i> "T" slew to desired position and press PICK ENTER
Send the Requested Altitude to the Aircraft	
	1. Type: "DW S CID letter " <u>or</u> "S" trackball PICK ENTER dot in front of list entry
	2. Observe item dropped from downlink list, appearance of item in Status List, and up arrow in FDB

Respond Unable to a Downlink	
	1. View a downlink (see facilitator)
	2. Type: "DW U CID letter " <u>or</u> "U" trackball PICK ENTER dot in front of list entry
	3. Observe item dropped from downlink list
Respond Standby to a Downlink	
	1. View a downlink (see facilitator)
	2. Type: "DW Y CID letter " <u>or</u> "Y" trackball PICK ENTER dot in front of list entry
	3. Observe item remains in downlink list and downarrow remains in FDB

Suppress Downlink List	
	1. For the aircraft sent a standby response, Type "DW FLID"
	2. Observe removal of downlink list
Delete a Downlinked Message	
	1. For the aircraft sent a standby response, Type "DW FLID" to retrieve the downlink list
	2. Type: "DW D CID letter " <u>or</u> "D" trackball PICK ENTER dot in front of list entry
View Downlinks From Multiple Aircraft (see facilitator)	
	1. Type "DW "
	2. Observe open downlinks for all aircraft
Identify Messages in Downlink List	
	1. Identify oldest message from all aircraft
	2. Identify newest message from all aircraft
	3. Identify newest message from one aircraft with multiple downlinks